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ORIGINAL MEMOIRS.

THE TECHNIQUE OF DIRECT TRANSFUSION OF BLOOD.

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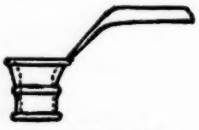
THIS paper is based on 225 experiments upon animals and 32 clinical cases. The major part of the work was done in the Laboratory of Surgical Physiology, Western Reserve University. The experimental part was undertaken in conjunction with Profs. Macleod and Haskins and Drs. Dolley, Hitchings, Cole, Lenhart, and Eisenbrey; the clinical part with Dr. W. E. Lower.

Experimental research into the technique included the availability of vessels by which blood could be transferred from one individual to another with the greatest certainty and under the best control. Transference of blood from vein to vein, though easy of technique, was uncertain in the rate of flow and had little power of overcoming resistance. By using an artery of the donor the blood was driven across under a certain amount of pressure, with a uniform rate of flow, readily overcoming a certain resistance and supplying fresh oxygenated blood. In using the peripheral artery of the recipient, it was found that the back pressure and peripheral resistance interfered with the free flow, and the valves of the peripheral veins

interfered with the flow from the artery of the donor. The proximal vein of the recipient, therefore, being the direct channel to the right heart, seemed the natural and most available route. The question of clotting at the site of anastomosis was eliminated by the use of a mechanical device in place of the Carrel suture. Dr. S. J. Mixter presented us with an ingenious device, in principle not unlike a Murphy button. From this and from the original method of Payr was developed our present instrument, shown in the cut, and now made by Messrs. J. C. Ulmer & Company, of Cleveland. By means of this tube anastomosis may be made so that intima is in contact with intima alone, without damage to this structure and without the possibility of any foreign body coming in contact with the blood stream. The tube has proved as successful in the clinic as in the laboratory.



Twice actual size.

In the clinical transfusions we have utilized the radial artery of the donor and the proximal end of any superficial vein of the arm of the recipient. The radial artery was chosen because it is easily isolated and may be readily adjusted to the position of the vein of the recipient. Unless contraindicated the donor and the recipient are each given a hypodermic injection of morphin twenty minutes before the transfusion. Before they enter the operating room, after their arms are prepared, and for the purpose of minimizing the psychic factor, a nurse places over their eyes a wet towel with the diverting explanation that the eyes must be protected from the bright light to prevent headache. The donor is placed upon an operating table of the Trendelenburg type so that should he faint the head may be readily lowered. The recipient is also placed upon an operating table with his head in the opposite direction from the donor. By the use of an infiltration anæsthesia of 0.1

per cent. solution of cocain, about 3 c. m. of the radial artery is exposed, and the smaller branches tied with very fine silk; a "Crile" clamp is applied to the proximal end of the artery and the distal end is ligated; the artery is then divided; the adventitia is pulled over the free end as far as possible and closely snipped off; a moist saline sponge now covers this field. Three or four cm. of a superficial vein of the recipient is then likewise freed; the distal part ligated, the proximal closed with a "Crile" clamp; the distal part is divided with scissors, the adventitia drawn out as far as possible and closely snipped off; the vessels are then inspected and a cannula whose bore is larger than the actual tissue thickness of either vein or artery is selected. The vein may then be pushed through this tube, after which the freed end is turned back like a cuff and snugly tied in the second groove. During this time the handle of the cannula is steadied and manipulated by means of a forceps. If the artery is small or atheromatous and, therefore, firmly contracted or if it is contracted for any other reason, its lumen may be dilated by means of a mosquito hemostat, pushed into the lumen and gradually opened. The artery is then drawn over the vein and is snugly tied with a small linen ligature in the first groove. This completes the anastomosis.

The clamp is then removed from the vein, afterward gradually from the artery, when the blood stream will be seen to pass from the artery across to the vein, dilating the latter. However, the exposure and manipulation of the vessels, especially the artery, causes sharp retraction. The artery may contract so firmly as to obliterate its lumen. The constant application of warm saline solution and protection from the air will help materially in bringing about relaxation and, hence, a larger stream of bood. The pulse wave may be palpated in the vein. It is best to introduce the blood very slowly, watching carefully the result.

From our clinical and experimental research into technique we have reached the following conclusions: that the vascular systems of two individuals may be united so that intima comes in contact only with intima; that this may be

accomplished by the Carrel suture or by a special anastomosis tube, which is the method of choice; that blood may be transferred without clotting; that the use of the radial artery of the donor and any superficial vein of the recipient yields the best results; that the operation may be done painlessly; that the blood lost by the donor is regained in from four to five days; that the amount transferred is under the immediate control of the operator; and that the rate of transference should be carefully gauged because of the risk of overcharging the pulmonary circulation.

ARTERIOVENOUS ANASTOMOSIS.

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On July 19, 1906, a man forty years of age, while working in a pipe foundry, had both legs crushed by two 10-inch core bars, weighing about 900 pounds, falling on him; there was a simple fracture of the left leg, and a compound fracture of the right ankle. When examined under ether, the bones of the ankle and lower end of the leg resembled ice when broken in a towel; the anterior tibial artery was found to be severed and the tissues around the joint were so badly lacerated that it was questionable whether the posterior was intact or not. There was considerable shock, and it would have been almost impossible to detect any pulsation in either of the vessels. The long saphenous vein was cut also, and I decided to unite the proximal end of the anterior tibial artery with the distal portion of the vein. Blood was flowing from both vessels and I secured them temporarily with lightly tied silk ligatures until I could finish resecting the ankle.

When ready to unite the vessels I resected the artery above and the vein below the ligature, in order to get rid of the bruised part of the vessels. Two small silk sutures were passed through the whole thickness of the artery on opposite sides and then down into the lumen of the vein for about a quarter of an inch, and then out through the wall of the vein, and, when drawn tight and tied, invaginated the artery into the vein. The end of the vein was sutured to the artery by a continuous silk suture.

No clamps were needed to control the circulation, on account of the weak condition of the heart's action. The blood was still flowing from both vessels when the artery was invaginated, but no distinct pulsation could be detected. There was no leakage after the circular suture was introduced. The wound was packed with gauze and the sutured vessel covered with a flap of flesh which could be raised up for inspection of the vessel.

The foot was put under a constant drip of carbolic acid solution ½ per cent., and kept warm with a hot-water bag.

The following day the foot was warm and normal in appearance; the circulation seemed as good as in the other foot. Motion and sensation normal. About half an inch of the vessel could be seen a short distance above the suture line, and slight pulsations could be felt; it seemed to be fully distended.

The artery was intact the eleventh day after the operation and bled some from the outer coats when sponged. No distinct pulsations could be felt, but it seemed to be in a healthy condition, and was thought to be carrying a small current of blood. The walls of the artery were firm and tense, and a clot was in all probability forming, which in the course of the next few days completely filled the lumen of the vessel and caused it to slough, owing to its exposed condition.

I did not attempt to examine it again for several days, and, when I did so, I found only a sloughing cord, which I recognized as the vessels, but its condition was such that it was worthless as a specimen.

I think the vein probably supplied blood to the foot for two weeks until a new collateral circulation was established which grew stronger as the fibrin was thrown down in the vessel, constantly narrowing its lumen.

About four months later the bone showed a somewhat diseased condition, and the patient insisted upon having the foot amputated. Unfortunately this was done while I was in Europe, and nothing was found out as to how the circulation of the foot was carried on.

SURGERY OF THE VASCULAR SYSTEM.*

I. LIGATION OF THE DUCTUS ARTERIOSUS. By JOHN C. MUNRO, M.D., of Boston. II. ARTERIOTOMY FOR THROMBOSIS AND EMBOLISM. By FRANCIS T. STEWART, M.D., of Philadelphia. III. TECHNIQUE OF BLOOD-VESSEL SUTURE. By J. EDWIN SWEET, M.D., of Philadelphia. IV. ENDO-ANEURISMORRHAPHY. By CHARLES H. FRAZIER, M.D., of Philadelphia. V. ENDO-ANEURISMORRHAPHY. By JOHN H. GIBBON, M.D., of Philadelphia.

I. LIGATION OF THE DUCTUS ARTERIOSUS.

BY JOHN C. MUNRO, M.D.,

OF BOSTON, MASS.

THAT I may be allowed to bring this suggestion for a new operation before your Society, I ask on the basis that it has not been hastily conceived On the contrary, long ago I demonstrated its technical possibility on the cadaver of new-born children, and felt that it was justifiable on the living. At various times I have tried to inspire the pediatric specialist with my views, but in vain. Now, in view of the recent advances in cardiac surgery, for much of which we are indebted to the surgeons of this city, I will venture to place my ideas before you, asking that you do not dismiss them hastily.

Nineteen years ago I saw a healthy girl baby that, soon after birth, exhibited symptoms of some cardiac lesion, out of keeping with the general appearance of perfect health and development. On severe exertion, such as straining at stool, it would become cyanotic, and the cardiac beat would cease. At times the child would apparently die, only to recover as soon as the heart was stimulated with electricity. In a few weeks atelectasis developed for which I tried artificial expansion of the lungs under negative pressure in a pneumatic cab-

* Papers read before the Philadelphia Academy of Surgery, May 6, 1907.

inet. This met with only temporary success. Auscultation at this time revealed a cardiac murmur with the pulmonary rales, but cyanosis was not a marked feature. After death, which took place without œdema or marked cyanosis, examination showed an open ductus arteriosus lying easily within reach behind the sternum, without any other defect or lesion except a dilated right ventricle. The simplicity of the remedy was so striking that I at once made further dissections, and satisfied myself that it would be possible to ligate the duct provided a diagnosis could be made beforehand. In regard to making a diagnosis, however, my pediatric advisers were not reassuring. In the hope that it may be possible to detect such a lesion in time to allow surgical interference, I would urge those skilled in the diagnosis of infantile lesions to lend their aid.

To attempt to disentangle the confusion of signs that attach to the various congenital lesions of the heart would be folly. Only faint light can be gained from authorities like Vierordt and others.

In the new-born the duct of Botalli is a little over 5mm. in diameter and 10-15mm. long. The length increases generally up to the time of obliteration which normally is complete by the twentieth day. Thus there must be an early period in the infant's life when the patency of the duct cannot be considered as pathological. It seems as though auscultatory signs during this period would throw some light on those which we should expect when the persistence of the duct forms a pathological factor. Townsend, however, examined 100 new-born babies during the first three days of life with this in view, but was unable to hear anything distinctive.

The causes for a persistent duct are not known. It may be due to some histological variation in the circular fibres, or to an absence of the inflammatory reaction that normally obtains. Very rarely is there an aneurysmal condition, or is the duct so short that a direct intercommunication between the aorta and the pulmonary artery exists. The cases collected by Vierordt do not number a hundred, but that must be quite far from a correct estimate. It is not at all necessary that other

congenital anomalies coëxist with the anomaly under consideration. Most writers find hypertrophy and dilatation of the heart, and the pulmonary artery may exceed the aorta in diameter. In typical cases the foramen ovale is closed, but not because of the theoretical reason that an open duct is dependent on a foramen that has closed prematurely.

In typical cases cyanosis is wanting. One finds rather an anemia or later a waxy appearance. Cyanosis is less characteristic of this than of other serious cardiac malformations. In late life it may be present, however. Cardiac dullness is increased laterally, and there may be projection and pulsation of the dullness, leftwards, in the upper costal spaces. This projection is visible by X-ray. The pulse shows little change though Franck considers that there is a fall with inspiration and a rise with expiration. We may find true attacks of suffocation, and bleeding from the mucous membranes as in other serious malformations. A loud systolic whir conducted into the cervical vessels may be heard, but as a matter of fact there are no definite auscultatory signs established as yet.

Of 26 cases recently collected about half lived to puberty, but it seems as though this must be an unduly large proportion owing to the lack of autopsies in infants. Death follows from atelectasis, general œdema, pleural exudate, pneumonia, endocarditis, etc.

Among the cardiac anomalies to be differentiated is, first of all, an open foramen ovale. The distinguishing signs are not well determined and it is useless to take up the question here. In open ventricular septs, in congenital pulmonary stenosis, in persistent truncus arteriosus, where the patient dies as a rule shortly after birth, we must expect marked cyanosis. Congenital aortic-pulmonary communication and stenosis of the various ostia are so rare that they may be disregarded.

Why should we consider surgical interference in cases of open ductus arteriosus? Because in spite of the fact that some cases may live to puberty, the chances of which must be small, we have the one cardiac-valvular lesion which is, relatively speaking, superficial. Furthermore the anomalous vessel is of

good size, its ligation must be followed by instant and permanent restoration to a normal function of the lungs and arteries, and it can be reached by a short surgical route.

The operation I would propose, as demonstrated on the cadaver, is as follows. Under ether, which I prefer to chloroform in any case involving collapse of the lung, the sternum can be easily split along its centre or a little to the right, opposite the second costal cartilage. This is easily done with a knife. The sternal halves are then retracted, ample room for working being obtained. The right pleural cavity will probably be opened but the left one will not. Judging from analogous cases in surgery, this should not be serious, but if necessary the physiologist's apparatus for maintaining artificial respiration could be employed. I hardly believe that it would be needed. After retracting the thymus upward, the pericardium is exposed. Its reflection lies so high on the large vessels that the ductus to all intents and purposes is intrapericardial. In the upper angle the aorta will be seen on the patient's right and the pulmonary artery on the left. By following close to the aorta toward the under surface of the arch the ductus, as large as the aorta itself, will be seen as the first vessel to the left pointing upward and a little to the right. Both pulmonary branches lie too far posteriorly to be seen, and by keeping close to the aorta the main pulmonary trunk will escape injury. On pushing through the tissues by blunt dissection the ductus, theoretically, should be easily surrounded with a ligature. It is a question whether or not simply crushing it would not accomplish as much, and in case of necessity, I believe that it would be worth trying. After closing the anterior pericardial wound the sternum can be sutured or not and the skin closed.

Would it be justifiable to subject a child to this risk without knowledge of the exact lesion? In a case with beginning atelectasis or other evidences of impending death from circulatory disturbances, with a reasonable basis for believing that the duct were open, it seems as though such an operation would be justifiable. I doubt if it would materially hasten a fatal issue in case the diagnosis were not confirmed.

II. ARTERIOTOMY FOR THROMBOSIS AND EMBOLISM.

BY FRANCIS T. STEWART, M.D.,

OF PHILADELPHIA.

THE usual treatment for arterial obstruction involving the limbs and depending upon thrombosis or embolism, is in brief to keep the part dry, warm, sterile, and slightly elevated, in order to prevent gangrene, or at least limit it and cause it to assume a dry and circumscribed form. With the development of aseptic surgery and the progress which has been made in the suture of arteries more active measures demand at least consideration. These measures will vary according to the cause of the arterial obstruction, since the problems to be solved differ with the lesion encountered. We shall confine ourselves to the two forms which we have an opportunity to investigate by operation.

1. *Traumatic thrombosis* due to contusion of an artery.—By contusion we mean an injury produced by blunt violence which does not result in immediate dissolution of the continuity of the external coat of the vessel, in other words, such injuries as are often described as partial ruptures. The lesions found after a contusion of an artery vary with the violence of the contusion and the state of the arterial walls. The slightest grade, in which there is perhaps no change but a little ecchymosis of the vessel wall, may be disregarded, as such causes neither immediate signs nor remote ill effects. The older surgeons explained some of the cases of obliteration of an artery after contusion, by rupture of the vasa vasorum, and extravation of blood between the vessel and its sheath in sufficient quantity to press upon and considerably narrow the lumen of the vessel. This was supposed to be followed by a traumatic arteritis with consequent thrombosis. It is now known that in practically all instances the inner coats of the vessels rupture and that such leads to thrombosis. As in the application of

a ligature, although the force acts from without inwards, the lesions, owing to the friability of the internal coats are produced from within outwards. The injury may expend itself on the internal coat alone, leaving the outer coats intact and practically normal. The lesion here observed is a fissuring of the intima, which may be complete or incomplete, *i.e.*, involving the entire circumference or only a part thereof. Complete circular division is best seen after the application of a ligature. In contusions by blunt violence the fissures are apt to be multiple, and frequently involve only a portion of the circumference of the vessel, usually that first struck. The sole result of clinical importance is thrombosis with its consequences. If the fissure is small and incomplete, there may be a minute mural thrombus, which causes no interference with the blood current, but simply protects the wound until healing is complete. Obliteration of the vessel by clot is liable to follow, however, if the rent in the internal coat is large, if the fissures are multiple, if the tunic is sufficiently detached to wave in the blood stream, if the detached tunic is infiltrated with lime salts, if tight compression is applied after the accident, or if the state of the heart or the blood is such as to predispose to coagulation. The conditions just mentioned determine also the rapidity with which an occluding thrombus forms. It may immediately follow the injury or it may not develop for several hours or even days. Generally speaking, complete obliteration after a lesion of the internal coat alone is delayed, although in the femoral artery we have observed it to occur within a few minutes. Yielding of the internal and middle coats is much more likely to be followed by immediate thrombosis, since they curl up within the vessel in obedience to the elasticity of the middle coat. The adventitia maintains the continuity of the vessel and prevents extravasation, although the blood may make its way for some distance between this coat and the media, sometimes for an inch or more. Ordinarily the clot extends centrally in a conical form as far as the first collateral branch. Peripherally its length varies; it may fill the main branch and the smaller arteries or it may terminate like

the central portion near a collateral. Upon its extent and upon the activity of the collateral circulation depends the integrity of the limb. If the injury is confined to the artery alone, and the vessels are healthy and the collaterals abundant, no harm need follow. If the clot forms slowly, ample opportunity is afforded for the development of an adequate collateral circulation, which becomes progressively more efficient the more the lumen is closed; thus pulsation may never be absent from the peripheral vessels, even though the vessel at the contused point becomes impervious. If, however, the vessels are narrowed by disease, or if the collaterals are involved in the injury or pressed by extravasated blood or a tight bandage, the collateral circulation will be insufficient and the thrombosis may extend to the finer vessels. In either event the limb falls into gangrene. Another possible factor in the production of gangrene is the detachment of portions of the clot during the formation of the thrombus, the emboli plugging the smaller vessels and leading to circumscribed gangrene. In the absence of sepsis secondary hemorrhage does not occur.

The signs of obliteration of the vessel (pain, pallor, loss of pulsation, loss of heat, hypesthesia of anesthesia, paresis or paralysis) when marked are followed by gangrene, but when present in a lesser degree complete recovery is still possible. Such, however, is the exception and the limb usually perishes for several reasons. Unlike simple ligation, after which gangrene is comparatively rare, in a contusion the accompanying vein also may be involved and thrombosed. The collateral vessels too are apt to suffer from the trauma, or if they escape direct injury they may be compressed by the extravasated blood resulting from the associated laceration of the environing tissues. Of 34 cases of traumatic thrombosis collected by Lears 18 recovered, and of these only 4 escaped gangrene.

If the pulse alone has disappeared and there are no other signs of impending gangrene, the treatment mentioned at the beginning is all that is needed. A hematoma, however, should always be opened, in order to lessen the compression on the collateral vessels. If the hematoma is of large size, one can

never be sure that the artery has not been opened, hence in these cases incision has a double rôle, to permit evacuation of the blood and to ascertain the condition of the artery. The clots adhere strongly to and infiltrate the surrounding tissues, but the tissues should not be scrubbed in order to remove them. If the bleeding has completely ceased we believe it good practice to suture the wound without drainage, since the latter always predisposes to infection, particularly in bruised tissues.

On theoretical grounds ligation of the artery above the injured part has been suggested in order to prevent the detachment of emboli. If the pulse has disappeared, indicating complete obliteration of the vessel, no reason exists for this procedure; if the pulse is still present, although of lessened force and volume, we believe the chances of embolism should be accepted rather than completely to suppress the circulation. Although the possibility of opening the artery, removing the thrombus, then suturing the wound in the vessel has probably occurred to many surgeons we imagined at the time of our first operation that we were the first to put the idea into practice. On looking over the literature, however, we find that both Sabanajew and Lejars have attempted to relieve arterial obstruction by arteriotomy.

Sabanajew's operation was performed in 1896 (Höpfner, Archiv f. klin. Chir. Bd. 70, S. 417, 1903). His patient, suffering with polyarthritis rheumatica, was suddenly stricken with signs of gangrene of the leg depending upon obstruction of the femoral artery, which was believed to be due to an embolus. The femoral artery was exposed, but no occlusion found in the expected situation. Owing to the desperate condition of the patient, further search was deemed inadvisable, and the vessel was closed with sutures and the limb amputated at a lower level. The patient died 19 days later of endocarditis.

Lejars' (Bull. et mem. de lo soc. de chir. de Paris, 1902, p. 609), patient was a man, aged 26 years, who was caught between two cars, sustaining a severe contusion of the left inguinal region. Signs of thrombosis of the femoral artery were in evidence, and the foot became gangrenous. Six days after the accident the artery was exposed below Poupart's ligament, a soft black clot removed, and the wound in the vessel closed with sutures. The gangrene progressed, however, and one month later the leg was amputated below the knee.

For our first case we are indebted to Dr. Robert G. Le Conte, who was absent from the city when the patient was admitted to the Pennsylvania Hospital, June 20, 1905. The patient was a man, aged 60 years, who presented all the evidences of advanced atheroma, with mitral regurgitation and hypertrophy of the heart. He had been squeezed between the tail-board of a wagon and a wall. Over the lower portion of the left abdomen and upper part of the corresponding thigh was a diffuse swelling due to extravasated blood. The skin was unbroken and there were no other injuries. Both legs were bluish and covered with a network of small varicose veins. Pulsation in the tibial vessels was as strong and full on the left as on the right side. During the night of the same day, or about twelve hours after the injury, he complained of severe pain, first in the popliteal space, and later radiating down the leg to the foot and toes. The following morning we found the pulse absent from the tibial vessels and popliteal artery. The femoral could not be satisfactorily palpated because of the swelling mentioned above. The pain had disappeared, but the leg as far as the knee was pale and cold, and the toes and foot shriveled. Sensation was present but markedly reduced in the entire foot and leg. There was no power in the toes, and the ankle could be flexed only with difficulty. Movements of the knee were unimpaired. The thigh was warm and apparently in the same condition as on admission. Owing to the condition of the thigh, the very sudden onset of symptoms, and the seat of the initial pain, it was believed that a large clot embolus had been swept from the point of injury and lodged at the bifurcation of the popliteal. About 12 hours after the onset of pain and 24 hours after the injury the patient was anesthetized with ether, and the popliteal artery opened by a small longitudinal incision. There was a slight flow of dark blood, but no clot could be found. A probe was gently passed up into the artery for about 6 inches and no obstruction found nor flow of blood induced. The wound in the artery was closed with through-and-through silk sutures and the skin approximated. A longitudinal incision was next made over the femoral artery, from just above Poupart's ligament downwards. The sartorius muscle had been ruptured and all the tissues were infiltrated with dark clots. The vein was uninjured. The artery was not discolored, but was hard to the touch from Poupart's ligament down to its bifurcation.

Poupart's ligament was severed in order to permit an assistant to grasp the vessel above the thrombus, and the artery was opened by a longitudinal incision.

After removing the clot, which was almost black in color and firmly adherent, it was discovered that, like a valve, a calcified portion of the intima had been turned into the artery from the anterior wall, probably occluding it one-half. The posterior wall of the artery, although calcareous in places, was apparently uninjured. The detached atheromatous plate was removed, and the compression on the artery diminished for an instant in order to wash out any remaining debris. The artery was then closed with through-and-through silk sutures. The circulation was immediately reëstablished, but after the lapse of a brief period pulsation below the injured point ceased. The arterial stitches were then removed and the vessel again found filled with clot. This was removed and the artery resutured. The same phenomena were repeated, and the hopelessness of securing a patent lumen by simple removal of the thrombus realized. The injured portion of the artery was therefore excised by a diamond-shaped incision, with the idea of closing the wound transversely. This, however, was found to be impossible, so that the artery was completely severed and each end split on the posterior wall, the flaps thus formed being turned outwards and the segments of the artery united with through-and-through silk sutures, bringing intima in contact with intima. Although the circulation was again reëstablished, at the time the skin wound was sutured pulsation in the artery below the site of anastomosis had become very feeble and no pulse could be felt in the tibial vessels. The gangrene, which was of the moist septic type, progressed rapidly and the limb was amputated through the upper thigh 10 days later by Dr. Le Conte. The flaps subsequently sloughed and reamputation was performed about one month later by Dr. Hutchinson. The patient finally recovered.

The chief difficulty in an operation like the foregoing is to prevent the reformation of the thrombus. The clot intimately adheres to the internal tunic and can be completely removed only with some difficulty, thereby subjecting the delicate lining membrane of the artery to further injury. If the artery is

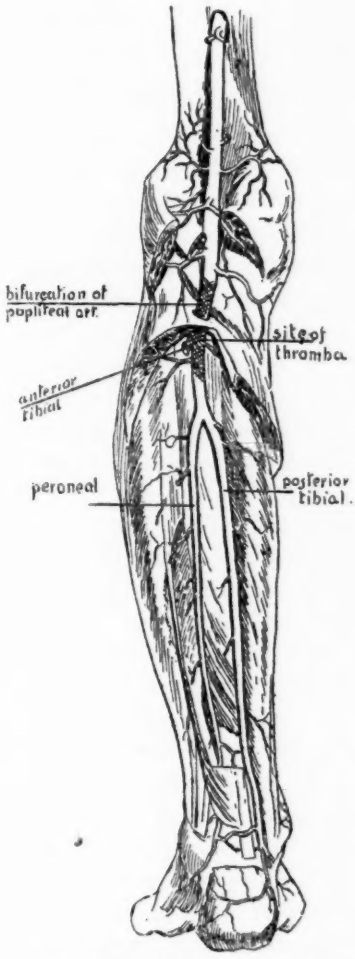
simply opened, the clot removed, and the vessel sutured, the cause of the thrombosis, *i.e.*, the multiple cracks in the intima or the curling up of the internal coat, is not suppressed, and the thrombus will quickly reform as it did in our case. There are several ways in which this may possibly be prevented. If the contusion is sufficiently limited, the injured portion of the artery may be resected, and the vessel anastomosed by Carrel's technic. The advantages of this method over Murphy's anastomosis by invagination are quite obvious, as the latter considerably diminishes the lumen of the vessel and does not permit the removal of as much artery as the former. The extent of vessel which may be excised without exerting too much tension on the sutures will vary somewhat with the situation; thus in resection near joints flexion may be utilized to diminish tension, while in other regions, particularly where the artery is bound to the surrounding parts by branches, it will be impossible to effect anastomosis after the removal of a large extent of vessel. In the latter instance severances of the collaterals would probably facilitate this manœuvre, but generally would be contraindicated. Kümmel was able to approximate the ends of a femoral artery after resecting two inches, during an operation for cancer of the inguinal region. Another method of restoring the circulation after traumatic thrombosis which at once suggests itself is to substitute a segment of a vein for the injured portion of the artery, a procedure which has already been employed in the treatment of aneurysm. Whether or not the operation is feasible cannot be definitely stated at the present time. Experimentally varying results have been obtained. Höpfner transplanted a segment of a vein to an artery in 10 animals. The vein at once became twice the size of the artery. The twirling of blood within it could be seen and, as in aneurysm, this led to thrombosis. Efforts were made to prevent the dilatation of the vein by doubling it, *i.e.*, by turning one end back like a cuff, and also by suturing the surrounding tissues over it. The ultimate results were negative, as secondary hemorrhage occurred in one and thrombosis in all the others. The success obtained

by Carrel in the transplantation of vessels in animals is well known and need not be recited here. Whether or not the companion vein should be employed for this purpose would depend upon the artery involved. One would not think of transplanting a segment of the popliteal or the femoral vein to its accompanying artery, as in case of failure both the arterial and venous circulations would be suppressed and the chances of gangrene very great. Probably the best vein to substitute would be the external jugular, although one of the brachial veins or even the opposite femoral vein might be employed. If the saphenous vein is sufficiently large, it likewise might be transplanted. In the arm where there are two venæ comites one of these could be selected.

Embolism.—The difficulty mentioned above would not be encountered in dealing with an embolus soon after its lodgment, indeed the chances of thrombosis would be no greater than after the most favorable form of arteriorrhapy, since the intima is likely to be smooth at the point of impaction of the embolus. Case two we submit as one of embolism, although we have no means of definitely excluding primary thrombosis. As an impacted embolus quickly becomes the nucleus of a thrombus, the exact diagnosis from the standpoint of arteriotomy is unimportant. The important thing is the condition of the intima.

The patient was a man, aged 61 years, who had never been seriously ill before. He was suddenly attacked with generalized abdominal pain, vomiting, and constipation. This persisted for two days, at which time we saw him with his physician, Dr. James M. Montgomery, who feared the case might be one of intestinal obstruction. There was no fever, the pulse was about 100, and the intrathoracic organs normal. The abdomen was flat, soft, and slightly tender in the region of the left kidney. Rectal examination was negative. The blood vessels were distinctly atheromatous. With the use of laxatives and enemas the bowels were finally induced to move, and the abdominal symptoms subsided. In the meantime the patient developed a cystitis with bloody urine, possibly as the result of the catheterization which

was found necessary at the beginning of the illness. About five days after the abdominal pain subsided the patient experienced a sudden excruciating pain in the right foot, which rapidly



Showing thrombus in popliteal artery.

extended to the lower third of the thigh, and was accompanied by pallor, loss of heat, loss of tactile sensation, inability to move the limb, and coldness. We saw him the following day and found the limb cold as far as the middle of the thigh. The foot was

shriveled, and the leg purplish as far as the upper third. Pulsation could not be felt in any of the vessels below the bifurcation of the femoral. Thirty-six hours after the onset of pain the patient was sent to the Jefferson Hospital, and the common femoral artery exposed by a longitudinal incision. It pulsated vigorously to within one inch of the bifurcation. From this point to the bifurcation it was hard, and below the bifurcation collapsed. The vessel was isolated, compressed, and opened by a longitudinal incision about one inch long. The thrombus was Y-shaped, corresponding to bifurcation, the base of the Y being about one inch long and tapering at the tip. The limb corresponding to the superficial femoral was ½ inch long and also tapering at the tip. The limb corresponding to the deep femoral was one inch long and likewise tapering. The color of the thrombus was dirty white, with bright red spots and black blotches, except the terminal ½ inch of the limb corresponding to the deep femoral, which was jet black. The intima was smooth, although the vessel wall was decidedly thickened. On removal of the thrombus blood flowed freely from the peripheral part of the deep femoral, but not from the peripheral part of the superficial. The vessel was closed with a continuous through-and-through suture of silk, and over this a second layer uniting the outer coats only. Pulsation immediately reappeared in the femoral below and in the popliteal, but not in the tibial vessels. The skin wound was closed without drainage. After operation pulsation continued in the popliteal about one-half the strength for three days, then began to grow weaker, finally disappearing on the eighth day. In the meantime a large vessel on either side of the patella (superior external articular, anastomotica magna) pulsated more vigorously as the pulsation in the popliteal became weaker. The pain in the leg continued, being particularly marked in the popliteal space. The line of demarcation which formed was an irregular oval, the inside reaching to the junction of the lower with the middle third of the leg, and the outside to the junction of the upper and middle third. In the deeper structures the gangrene ascended to a higher level. Forty-two days after the first operation the leg was amputated below the tubercle of the tibia, lateral flaps of equal length being employed. About 15 ligatures were necessary, and the bone bled freely on section. The popliteal artery contained a

small clot, and a probe passed up into the artery for several inches caused a slight flow of blood.

Perhaps the first thought which strikes one after reading the above cases is the inability which was encountered in two instances to locate definitely the obstruction by the mere symptoms. In our first case we feel sure that the mistake would not have occurred could we have palpated the femoral artery itself. It seems that the symptoms are caused, not by the thrombus itself or by even the sudden impaction of an embolus, but by the result of the arterial obliteration, *i.e.,* the acute anemia, thus the pain, etc., are referred to the area from which the blood is excluded, and not to the seat of obstruction. It will be seen, however, that the operation of thrombectomy or embolectomy, if it may be so called, can be readily performed without danger of secondary hemorrhage. We believe it to be indicated particularly when the intima is smooth, and that to be of value it must be performed as soon as possible after the arterial obstruction develops. Even though the vessel again becomes obstructed with clot, as in our second case, this may form slowly and give the collateral vessels a chance to dilate, thus saving at least a portion of the limb.

III. TECHNIQUE OF BLOOD VESSEL SUTURE.

BY J. EDWIN SWEET, M.D.,

OF PHILADELPHIA.

If we will remember for a moment that the first suggestion of repairing wounded blood vessels, as well as the first attempt to carry out the suggestion, dates from the year 1759, —when Hallowel, an English surgeon, at the suggestion of his fellow, Lambert, attempted to repair a wounded brachial artery, and perhaps succeeded,—it is not surprising that many have endeavored, experimentally and clinically, to elaborate a successful technique for the suture of blood vessels.

Longitudinal wounds of blood vessels, and transverse wounds involving only a portion of the circumference, are easily repaired, the technique of such procedure being the common property of all surgeons of experience. The question before us to-night is the technique of the repair of wounds which completely divide the vessel,—the question of the end-to-end anastomosis of blood vessels; a question involving accident cases, the treatment of aneurisms, the transfusion of blood from one human being to another, and, possibly, the transplantation of organs.

A most superficial consideration of the tubular structure known as a blood vessel leads to the conclusion that such a tube may be reunited in one of four ways,—I mean from the mechanical standpoint; 1. the ends may be brought as nearly as possible into their original position, approximating the various coats of the vessel to each other; 2. the edges may be everted, turning the cut edges outward; 3. one end may be inserted into the other end, invagination; 4. a mechanical aid may be employed

I am personally inclined to the belief that the method of exact end-to-end approximation,—the method which has given such remarkable results in the hands of Carrel and Watts,—is easier of execution, and since it accomplishes that great

surgical desideratum, the restoration of tissues as nearly as possible to their original position, is perhaps theoretically correct.

There seems to be unity of opinion as to the choice of suture material,—fine silk, of a size carefully chosen so that it will completely fill the hole left by the needle. The needles should be of the smallest possible size, round, either straight or curved, according to the individual and the site of operation. Experimenters are further agreed that the stitches should include all the coats of the vessel, since the penetration of the intima is a matter of no consequence.

The actual technique is, then, as follows: the exposed vessel is clamped by some means which must be very gentle, the simplest and best clamp being, in my opinion, the one devised by Herrick. The loose connective tissue of the external coat of the vessel must then be dissected away, the best procedure being to draw it down over the cut end of the vessel and to snip it off even with the vessel end; it will then retract, leaving the vessel free. This must be done, else the loose tissue will interfere by being dragged with the suture into the needle holes. All insult to the vessel wall, such as grasping it with forceps, must be religiously avoided. If the edges of the wound have been crushed they should be freshened by resecting a bit with a very sharp scalpel; since the cut of scissors is always a crushing cut they should not be used.

Three tension sutures of fine silk, impregnated with vaseline, are then laid at equidistant points of the circumferences of the vessel ends. An assistant then applies traction to two of these guide sutures in turn, stretching the portion between the two sutures into a straight line, facilitating the laying of the continuous suture, and preventing a narrowing of the lumen. If at this time the third tension suture is weighted by means of a hemostat the circumference of the vessel will be arranged in the form of a triangle, the points of which are determined by the three traction sutures, and there will be no danger of catching the opposite wall while laying the suture. The suture is a continuous, overhand stitch,

through all the coats; the separate stitches should be drawn just tightly enough to secure absolute approximation, but not too tightly else the tissues be everted; they must be laid very close together. After the completion of the suture and the removal of the clamps there will often be some hemorrhage; if this is too free a few interrupted stitches may be laid, but a considerable hemorrhage will almost always stop under gentle digital compression. I wish to emphasize this fact, because of its bearing upon the later theoretical discussion. The danger of aneurism formation is very small; secondary hemorrhage is also as rare.

Now this sounds very easy, and, in truth, it is not very difficult, except for the extreme delicacy of the needles and the silk, and of the vessel walls; it is unusual surgery, since it partakes of the art of the watch-maker. Why, then, cannot everybody succeed in performing these simple, though delicate operations? Why do we read reports varying between absolute failure and uniform success? Why, out of four operations on the neck of the same animal, do we sometimes find the arteries perfect, the veins thrombosed, or the veins patulous and the arteries closed, or only one success, or all failure, or all success? This is the question which, I think, leads us far away, into the fields where fact and theory too often establish a circulus viciosus.

In the first place, every author since Jassinowsky, whose work formed the first real contribution to our knowledge of this subject, has emphasized the necessity of a perfect aseptic technique. Carrel goes so far as to express his opinion that under ordinary "aseptic" conditions there are always a few bacteria which gain entrance to the wound; now these are so few that under ordinary conditions the tissues are able to destroy them. Not so in blood vessel surgery,—here we must have "absolute asepsis."

That infection around an uninjured blood vessel will cause thrombosis is banal. But I cannot believe that infection is the cause of the frequent thrombosis after blood vessel suture for several reasons; first, we find thrombosis with none of the

usual macroscopic signs of infection, and, secondly, an early examination will show small non-occluding thrombi, and older specimens will show such thrombi completely healed over. In the third place, I have often observed that a thrombus will form in a sutured vessel, especially a vein, within a few moments after the clamps are removed, certainly hours too soon for these few bacteria to have caused it. Further, if this thrombus be removed by gently "milking" the vessel, another thrombus will replace it. In other words, the causes of thrombosis lie nearer at hand than bacterial action.

Just what happens when a blood vessel is wounded? The final processes of repair have been studied sufficiently to enable us to say that the vessel wall is completely repaired. The wound of the interior is covered with proliferated endothelium; some elastic fibres may regenerate, though the elastica is possibly not as perfectly repaired as are the other coats; the external coats are reconstructed by that excess of reaction so common in Nature as to be universal, and the vessel wall becomes stronger at that point than it was before the injury.

The problem of the coagulation of the blood is an extremely complex one. We know various factors in the process; we know that foreign bodies and roughenings of the intima favor coagulation; that an interference with the free current of the blood is a favoring factor. We know that the tissues contain a substance or substances which cause rapid coagulation of the blood plasma, and that these substances are present in the tissues of the vessel wall. The formed constituents of the blood also contain these same or analogous substances. Calcium salts are necessary for the formation of fibrin. Experiments upon the vessels of animals whose blood had been made incoagulable by injections of hirudin or of peptone have shown that another process enters into the play, an agglutination of the blood plaques or platelets.

It is not necessary for us to decide between the theories concerning what happens first, or what happens further, as whether the action is a ferment action or whether it is not.

Let us think of the action of some of the factors in coagulation which I have mentioned. The suture, being inelastic, must offer a point where the current of the blood is more or less influenced; the sutures are the foreign bodies; the holes in the intima are rough; the tissue coagulins contained in the vessel wall have access to the blood through the needle holes; blood platelets are deposited in the wounds of the intima, even in incoagulable blood, and we know that a true coagulum can start from such a deposition of platelets. Further, if two factors are united in these biological phenomena, the result is usually much greater than the sum of the separate action of each factor.

That some coagulation occurs in every case seems to me to be proven by the statement to be found in every report of extensive work,—that slight hemorrhage is to be controlled by gentle digital compression. Such a method could only stop hemorrhage, it seems to me, by favoring the filling of the needle holes with a coagulum.

I therefore think that those who report uniformly successful results have succeeded not because they enjoy a monopoly of aseptic technique, but of mechanical technique. In other words, the man who will master the numberless details of asepsis in experimental work on animals, where matters are more complicated than in human surgery, is probably the man who will master the delicate mechanics of the operation. The vessels are brought together with the least possible stretching or narrowing of the lumen, thus affecting the blood stream as little as possible. The foreign body is made less active as a foreign body by impregnating the silk with vaseline. The silk is so chosen as to fill the holes made by the needles and thus prevent the admixture of tissue coagulins from the vessel wall. Having excluded these factors, the deposition of blood platelets, which, I believe, always fills the wound of the intima at least, may perhaps be insufficient to cause the formation of fibrin and thrombosis.

The exclusion of these factors brings me to the consideration of a mechanical aid to blood vessel anastomosis, which is

commonly called the method of Payr, but which, if my literary researches are correct, should be accredited to von Quirolo, his report appearing in 1895. The method consists in drawing the cut end of the vessel through a tube of glass, or ivory, or metal; the internal diameter of this tube is the same as the external diameter of the blood vessel. The vessel is then turned inside out, back over the tube, so that the intima is on the outside. This cuff is fastened in place by a ligature, and is then inserted into the other end of the blood vessel, which is fastened in its place by a second ligature. The ligatures are prevented from slipping off the little tube by placing them over grooves cut in the tubes, or back of a raised thread made on the outside of the tube. By this method broad surfaces of endothelium are placed in contact, and no wounds are made by the needles; the cut edges of the vessel, exuding coagulins, are entirely outside the vessel lumen. The method does not appear to have given especially good results except for temporary anastomoses, as in transfusion, where it seems to me to approach the ideal. It is not so easy to execute as it may seem. Crile has improved upon the original suggestions by attaching a handle to the tube, which greatly facilitates the eversion of the vessel.

The theories of the coagulation of the blood have carried me far out to sea; I was left there by the following facts concerning an operation little known, because of no practical importance. In 1876 a Russian army surgeon named Eck conceived the idea of making an artificial opening between the portal vein and the vena cava, in order to relieve the congestion in the portal system in cases of cirrhosis of the liver. He not only conceived this idea but executed it experimentally; and since that time the operation has been often performed, yet in no report do we find that thrombosis or embolism has resulted.

The operation has been done in several ways, none of which is calculated to prevent thrombosis. The vessels are brought together by interrupted sutures; wires or threads are then placed in position in the lumen of each vessel so that

when the small scissors, the blades of which are fastened to the wires, are drawn through, after a second row of sutures has been laid, each blade must cut a linear incision through the wall of its respective vessel, an incision limited by the points of entry and exit of the guiding wires; the line of this incision is then enclosed by a second row of interrupted sutures parallel with the first, and the scissors are pulled through between the two rows of sutures. In my own method the wire of an electro-cautery is substituted for the scissors. The portal vein is then tied off at the hilus of the liver, thus forcing all the blood through a torn or burned wound through all the walls of the veins. The interrupted sutures also pierce the intima.

We have then a beautifully torn, rough wound, sutures with no attempt to neutralize their action with vaseline, undoubted coagulation,—since we have no hemorrhage between the sutures, which are laid from one-sixteenth to one-eighth of an inch apart,—and yet no thrombosis. The explanation may be that the portal vein has no collateral branches to open and enlarge, and the blood is forced to pass through this artificial opening; but on the other hand the pressure cannot be so great as it is in an artery. It might be that the portal blood contains peptone-like bodies which inhibit coagulation, but this is hardly probable, for the portal blood coagulates outside the vessels as rapidly, if not more rapidly, than does blood from any other vessel. I have thought that the burned wound made by my cautery sealed the edges so that the tissue coagulins could not exude; yet equally good results have been obtained by using scissors; further, I have attempted to prove my idea by cutting the vessels of the neck with the cautery, and then joining them according to various methods; the results are possibly not so good as after the vessel wall had been severed by a sharp scalpel. In short, I am willing to admit that the processes governing thrombosis are not sufficiently clear to my own mind.

For the practical surgeon I feel that we may draw these conclusions: in any case where the anastomosis of a blood vessel is indicated, it should be tried; aneurisms and secondary

hemorrhages should not occur. If immediate thrombosis occurs we would be as well off as though the vessel had been ligated; if gradual thrombosis occurs, we might well hope that such a process would be more favorable to the formation of a collateral circulation than would immediate ligation; and if we should succeed, the literature of surgery would undoubtedly be enlarged and enriched.

IV. ENDO-ANEURYSMORRHAPHY (MATAS).

BY CHARLES H. FRAZIER, M.D.,

OF PHILADELPHIA.

ONE of the most fascinating chapters in the history of modern surgery concerns the application of the suture as applied to lesions of the vascular system. These revolutionary measures have attracted wide attention not only because of their applicability to the treatment of the everyday lesions of the vascular apparatus, but because in simplifying the technic of direct transfusion they open a field of speculation, the possibilities of which are just beginning to dawn upon us.

The history of the development of the suture in the surgery of the vascular system and its applicability to the treatment of aneurysm has been so graphically described by Matas that I will confine my remarks to my personal experience with his operation, adding such comments as may be suggested by the conditions which presented at or after the operation.

CASE 1. B. T. (University Hospital, No. 1313, Series 2.) *Popliteal Aneurysm: (Sacciform) Endo-Aneurosmorrhaphy (reconstructive): Recovery.*

A colored man, 38 years of age, was referred to me by Dr C. S. Weeks in April, 1906. He was a waiter by occupation. He had had syphilis about eighteen years ago and was addicted to the free use of alcohol and tobacco. Eight months ago (September, 1905), the patient began to complain of a dull pain in the popliteal space. The knee joint felt stiff and the patient thought he had rheumatism. The pains and stiffness increased but it was not until two months later (December, 1905) that he noticed a small swelling, about the size of a chestnut, in the right popliteal space. The swelling gradually increased in size, until one month before his admission to the hospital, when it began to increase so rapidly that he was obliged to give up his work.

Upon examination there was found a pulsating tumor occu-

pying the lower portion of the popliteal space measuring 10 cm. in its longitudinal and 11 cm. in its transverse axis. The circumference of the limb over the tumor was 32½ cm. as compared with 29 cm. on the unaffected limb. The leg below the aneurysm was somewhat swollen and the superficial veins quite prominent. There was a visible expansile pulsation and a marked bruit on auscultation. Pulsation could not be felt in the anterior tibial vessel. Operation. April 28, 1906. Under nitrous oxide-ether anæsthesia, an Esmarch tube having been applied to the thigh, a longitudinal incision was made directly over the tumor. Upon opening the sac a careful inspection proved that we were dealing with an aneurysm of the saccular or sacciform type, having but one communication with the parent artery. The operator then proceeded to remove the clot which partially filled the aneurysmal sac. This proved to be a rather slow process because the laminæ, particularly the deeper ones, were well organized and quite adherent to one another. These were peeled off as one peels an onion. Microscopically these clots were found to be well organized, being composed of a stroma of young connective tissue within which were sprouting newly formed blood vessels When the sac wall was finally stripped of its clots the single communication with the artery was closed with a continuous silk suture and the sac cavity obliterated by means of two layers of fine silk sutures. The cutaneous wound was closed with silk worm gut suture, the dressing applied, and fixation assured with a posterior splint. The post operative convalescence was devoid of interest. At no time was there any cause for apprehension as regards the vitality of the limb below the seat of operation. The temperature of the foot on the affected side was unaffected, the limb was not swollen so that I was quite sure neither the arterial nor venous circulation had been affected by the operative manipulations. The patient complained of numbness in the limb for a few days but this sensation soon passed off. There was some suppuration in the upper layers of the wound. While accidental infection may occur in any wound there are two factors, which in this particular operation may be regarded as predisposing causes, one traumatism, such as may be inflicted in removing the laminated clot, the other, impairment of circulation; Matas, in speaking of the chief points to be observed in closing the wound, says "too tight or too many sutures must be avoided in order not to compromise the circulation of the sutured tissues."

When the patient was discharged from the hospital there was no pulsation detected in the anterior tibial artery, a condition which was noted before the operation. The patient was examined in October, 1906, nine months later, when there was no signs of recurrence.[1]

Comments.—In this case I was surprised with the comparative simplicity of the procedure from the technical standpoint. There was of course no difficulty in rendering the field of operation bloodless, the aneurysm was easy of access. At no time was there any danger or fear of injuring the popliteal vein, which there would have been had any attempt been made to remove the sac. Whatever difficulty there may have been was entailed in removing the laminated clot and in determining when the intima had been reached. The layers which composed the clot were firmly adherent one to the other, in fact there was, as proven by microscopic examination, absolute union between the layers. A good deal of force had to be applied to separate them from the sac wall, and on several occasions I thought the intima had been reached only to find one or more layers still adherent. With more experience and with greater familiarity with the gross appearance of the structures involved this step of the operation could have been conducted more expeditiously. The necessity of removing everything necessary to lay bare the intima is apparent; inasmuch as the success of the operation depends absolutely upon the apposition and union of the serous coat of the aneurysmal sac and arterial orifice. The single communication with the parent artery was situated at the bottom of the sac near its upper extremity and not in the middle. We are accustomed to see the communication with the artery, in cases of saccular aneurysm, diagrammatically represented about the middle of the sac. This was the position in which I expected to find it in this case; failing to find it there, it was some time before I discovered it near the upper pole.

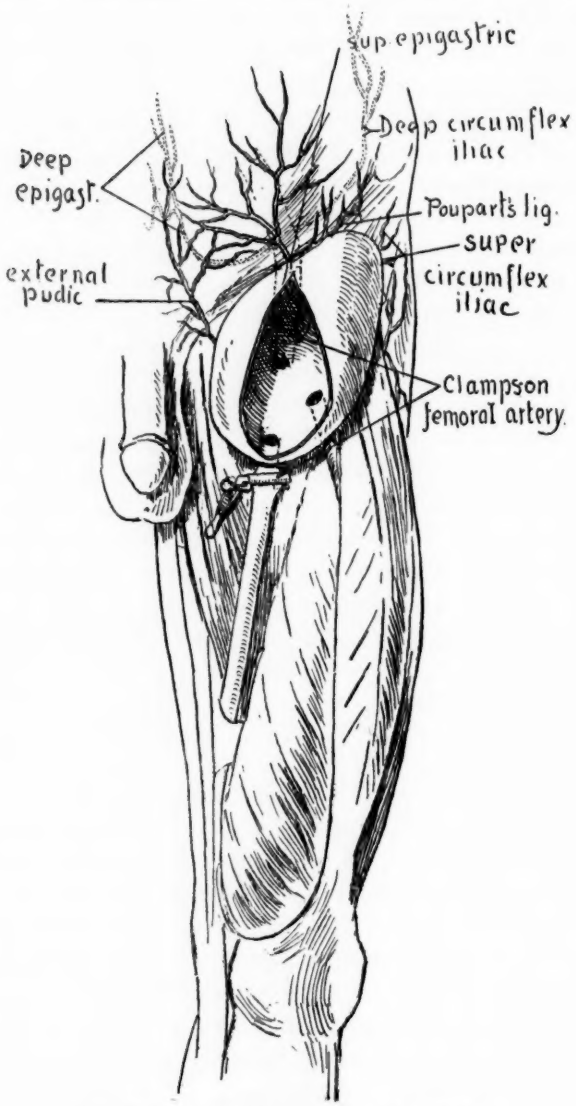
[1] The patient died January, 1907, of pneumonia, at which time it was reported that there was no recurrence.

CASE 2. T. S. (University Hospital No. 1785) *Femoral Aneurysm* (*Sacciform: two communications with parent artery*) *Endo-Aneurysmorrhaphy,* (*obliterative*) *Gangrene, Amputation, Recovery.*

A colored man, 34 years of age, presented himself for treatment at the University Hospital, October 8th, 1906. He had contracted syphilis eight years ago, he used alcohol very freely and his occupation, as a porter, required him to lift heavy objects. Although by occupation and habit he had paved the way for aneurysmal formation he attributed the lesion to an injury which he had received three months ago. He struck the groin against the corner of a table and two weeks later he noticed in the femoral region a small lump, which increased in size and soon began to pulsate. An examination revealed a powerful subject with numerous cicatrices on the cutaneous surface, the result of old syphilitic lesions. The arteries did not seem to be sclerotic. Extending from Poupart's ligament to the apex of Scarpa's triangle and some 12 cm. in width was the aneurysmal tumor. Pulsation was controlled by pressure upon the femoral artery just below Poupart's ligament. Below the knee the limb was swollen, the patient complained of a sense of numbness about the knee, and of so much pain that for the past two weeks he has been scarcely able to walk. The character of the operation and its risks were clearly explained to the patient.

Operation.—October 10, 1906. Owing to the situation of the aneurysm, close under Poupart's ligament, it was quite evident that it would not be feasible to use a tourniquet. I proceeded accordingly to close temporarily the external iliac artery: this was done through an oblique incision just above and parallel to Poupart's ligament; an arterial clamp was applied and as an additional precaution a heavy silk ligature was thrown around the vessel, but not tied. This accomplished, a vertical incision was made over the site of the tumor, the aneurysm exposed, the artery below the aneurysm isolated and an arterial clamp applied here. Having taken the precaution to close the artery on both the cardiac and distal side of the sac, I hoped to be able to proceed with the operation unembarrassed by hemorrhage. Upon opening the sac, however, a large column of blood spurted out a foot or more above the table. My first thought was that the blood which made its escape represented what was present in

the aneurysm under more or less tension, but it soon became apparent that active bleeding was going on in the aneurysmal sac.



Femoral aneurism:—showing openings in floor of sac.

The bleeding was so profuse as to give cause for alarm. I have never seen so free and apparently uncontrollable hemorrhage.

The cavity was packed firmly with gauze, and an attempt made with firm pressure to control hemorrhage, but this was only partially successful. The pulse soon rose to 160 then to 170; normal saline solution was given by hypodermoclysis and other appropriate remedies. It was quite evident that some more effective means must be adopted to save the patient's life. I proceeded as rapidly as possible to expose little by little the inner wall of the sac and found two openings, one on the floor and one on the lateral aspect of the sac, from both of which the blood was streaming. Direct pressure was made upon the openings with the tips of two fingers, and by this means only was bleeding finally arrested and an opportunity offered to inspect the sac. The latter was found to have three openings, two on the floor and one on the side. These were closed as rapidly as possible with fine catgut sutures. The laminated clot was then peeled off, as in the first case, and the cavity of the sac obliterated by taking up the lateral folds and bringing them together with a continuous mattress suture after the manner prescribed by Matas. Three layers of sac superimposed over the arterial orifices sufficed to obliterate most of the aneurysmal sac; there still remained a small pocket at the upper pole, so far distant from the artery itself, that there seemed to be no objection to leaving it undisturbed. A drainage tube was introduced, the wound closed with interrupted silk worm gut sutures. After the dressing was applied the limb was enveloped in cotton and elevated. The patient's condition when he left the table was better than it was earlier in the operation. On the following day the toes were exposed and found to be warm, but anæsthetic; there was no pulsation in the dorsalis pedis. On the fourth day the patient complained of pain in the calf of the leg, there was marked tenderness when pressure was exerted over the course of the posterior tibial vessels, the limb was evidently swollen, and the foot was cold. It was quite evident that the circulation was seriously impaired and that gangrene would follow. The line of demarcation soon formed and the limb was amputated. A careful dissection of the specimen made for me by Dr. B. A. Thomas revealed the cause of the gangrene in a thrombus which had formed in the popliteal vessel just above its bifurcation, and extending for a short distance into both tibial vessels.

This case has been presented in greater detail than would at first sight seem warranted, because of two more or less distinctive features; the tremendous hemorrhage and the gangrene. Of the 35 or 40 cases that are on record this is the first case in which gangrene followed an uncomplicated endoaneurysmorrhaphy. This was a very unfortunate occurrence, inasmuch as one of the strongest arguments in favor of the Matas operation is its safety to the patient and to the parts involved, because of the non-interference with the collateral circulation and the avoidance of gangrene. The operation is founded upon such sound principles and the mode of procedure has been so carefully elaborated by Matas that I am quite willing, if not anxious, that in this case some error in technique may be discovered which will account for the thrombus formation and ultimate gangrene. From the subjective and objective symptoms it would seem that the thrombus had obliterated the vessel on the third or fourth day. The process may have originated at the site of the thrombus or it might have been due to the lodgment at that point of an embolus. There was an accidental infection of the wound, but there could be no relation of cause and effect between an infection above the seat of the aneurysm and the thrombus below the aneurysm, a segment of obliterated vessel intervening between the two. It seems much more reasonable to attribute the thrombus formation to an inadequate collateral circulation.

The second rather distinctive feature was the tremendous hemorrhage. One of the conditions which Matas considers essential for the success of the operation is provisional or temporary hemostasis. The aneurysm should be so situated that provisional hemostasis may be obtained by controlling the proximal arterial supply of the tumor on the cardiac side. "When circular constriction (as in my case) is impossible great care must be observed, writes Matas, in securing the distal as well as the cardiac side of the main trunk in order to obtain a comparatively bloodless field." Accordingly I closed temporarily with arterial clamps the vessel on the distal and proximal side with what results has already been told.

While the hemorrhage was most profuse, it was at the same time a most instructive demonstration, for it proved at once how utterly futile in this case it would have been to have practiced one of the older operations, particularly ligation, and illustrated beautifully the point upon which Matas has so frequently laid stress, namely, that the complete obliteration of the sac and the freedom from recurrence depends not only upon closure of the parent artery, but the collateral branches.

Had the reconstructive rather than the obliterative type of operation been carried out gangrene might not have occurred. There were two communications with the parent artery, but there was nothing left by which the course of the parent artery between the two openings could be recognized. It was blended with the aneurysmal sac throughout its circumference. Even had it seemed possible or desirable to reconstruct the artery the operation in this case could not have been carried out in the presence of so much free and uncontrollable bleeding.

Because of the evidence of so free a collateral circulation I was disposed to give a favorable prognosis as to the preservation of vitality and was much surprised when gangrene developed. While there is an erroneous impression that the Matas operation implies the reconstruction of the artery, "for all practical purposes the preservation of the continuity of the artery is not assential to success and is only indicated positively in the sacciform aneurysm with a single opening, when the parent artery already exists as a formed vessel." (Matas.) With this experience, however, I should be disposed in the future particularly in femoral aneurysms and under favorable conditions to attempt to reconstruct the artery, rather than depend entirely upon the collateral blood supply.

V. ENDO-ANEURYSMORRHAPHY (MATAS).

BY JOHN H. GIBBON, M.D.,
OF PHILADELPHIA.

THE ideal operation for the cure of aneurism is one which arrests completely and permanently the circulation of blood in the sac, without interfering with the blood supply in the parts beyond the aneurism. These two objects have always been in the mind of the surgeon and numerous operations have been devised which have accomplished them in certain situations.

The Matas operation comes nearer the ideal than any other, and is more generally applicable. Certain aneurisms, like those of the thoracic aorta, are probably beyond the field of operative surgery, but in every accessible variety where the circulation can be temporarily controlled, the Matas operation can be employed. Accessibility and temporary control of the circulation are essentially necessary, and where impracticable the operation should not be attempted. These limitations, however, do not prevent endo-aneurismorrhaphy being more universally applicable than any other operation for the cure of aneurism. It is not, however, the general applicability of the operation which has caused it to take first rank as a radical cure, but especially the fact that it interferes less with the blood supply beyond the aneurism than any other.

The experimental work of Carrell, in this country, and of San Martin, Höpfner, Payr, Ullman, Jassinowski, Glück, and others abroad, together with the clinical and experimental work of Abbe, Murphy, Crile, Brewer, Hubbard and Matas, has shown with what readiness the blood vessels lend themselves to plastic operations. Suture, anastomosis, transplantation, substitution of vein for artery, arteriotomy for embolism, all of which have now been shown to be perfectly practicable, give some idea of the possibilities of vascular surgery.

The Matas operation has for its foundation this experi-

mental and clinical work. It having been shown that when intima is approximated to intima union occurs just as when two peritoneal surfaces are placed in contact, Matas conceived the idea of closing the openings of the blood vessels in the aneurismal sac and of obliterating the sac by approximating its walls. He first operated by this method in 1888,[1] and reported a case, but his paper attracted little attention. At the time of publication of his second paper, in 1903,[2] he had done this operation four times. He suggested two other possibilities; first, the repair of the artery in sacciform aneurism, and second, the reconstruction of the artery in fusiform aneurism when the openings of the vessel were on the same line and not too far apart. To show that these were good suggestions it is only necessary to point to the successful cases since reported.

Bickham,[3] in an excellent paper, has shown that the principle of endo-aneurismorrhaphy is equally applicable to all accessible arteriovenous aneurisms, a variety in which ligation is especially dangerous, because of the likelihood of gangrene resulting from obstructed circulation.

Matas' own papers are so complete and comprehensive that it is unnecessary to go minutely into the technique. Briefly, the operation consists in controlling the flow of blood in the diseased vessel by compression; the free incision of the sac from end to end; the evacuation of its contents; the closure by suture of the arterial openings in it; and then the obliteration of the sac by plication and infolding of the skin. In the case of a sacciform aneurism but one opening requires closure, and when this is done the caliber of the vessel is, of course, reëstablished. In the fusiform aneurism there are two courses open to the operator—one, of closure of the two openings of the artery into the sac, and of any collaterals which may originate within the sac, and then the entire obliteration of the sac by continuous rows of sutures; or, he may reconstruct the arterial caliber by suture over a catheter which is withdrawn before the last sutures are tied. Although I consider that the operation is no longer on trial, yet it is

important that all cases operated on should be reported in order to compare the results with those of the older operations. In Matas's last paper[4] he classified 34 operations performed by twenty-one American surgeons, and referred to 6 foreign cases done by three operators, in which there was considerable variation of the technique—so much in fact that he is not inclined to combine them with the American cases. He believes that there has been a great misapprehension regarding the technique on the part of foreign surgeons, many of whom have on this account disapproved of the operation. In this series of 34 cases there have been but two deaths, neither attributable to the operation itself. One patient died fifteen days after operation from associated pyelitis and nephritic coma, the wound having healed completely. The other patient died on the seventeenth day after operation. This patient had an aneurismal diathesis and after operation developed multiple aneurisms. He was first operated on for a ruptured aneurism of the right popliteal, the sac was extirpated; he then developed a left femoral aneurism which was operated on by the Matas method. Twenty days later the vessel above the aneurism dilated and ruptured at a point where a traction loop had been applied for the temporary control of the circulation. Ligation of the femoral high up was then done but suppuration took place and later gangrene of the foot. Six days after this a secondary hemorrhage occurred and the external iliac was ligated, the gangrene extended, and the leg was amputated in the mid thigh. The patient died in about two weeks from exhaustion. It should be noted that in this case neither secondary hæmorrhage nor gangrene took place until the vessel was ligated.

In none of the other cases did either hemorrhage or gangrene occur as a complication.

In considering the question of permanent cure, Matas divides the operations into obliterative, those in which the arterial openings were closed and the sac obliterated; restorative, those in which the aneurisms were sacciform and the arterial opening was closed without interfering with the circulation in the artery; and reconstructive, those in which a new

vessel was constructed from the aneurismal sac. There were 22 of the obliterative cases with no relapses; there were 7 restorative cases with no relapses; there were 5 reconstructive cases with 2 relapses. In one of these an amputation was done at the patient's request. In the other case a second operation was done, the openings in the sac being occluded by suture, and a cure resulted.

I have been able to add to this collection of 34 cases 3 from recent literature, (McCord,[5] Brown,[6] and Yocum[7]); a second case of my own, and a second case of Frazier's[8] making in all 5 additional cases. Two of these were reconstructive operations, both of which were followed by good recoveries without complications; one was a restorative operation with an equally good result; two were obliterative operations, in one gangrene occurring on the fourth or fifth day necessitating amputation, after which the patient recovered; and in the second, my own case, death occurred on the 59th day from uræmia, the patient having been in a bad condition from chronic Bright's disease at the time of operation. The wound in this case was practically healed and the œdema of the limb had disappeared. My first case was operated upon on October 26, 1904.[9] I examined this man a few days ago and there was no evidence of any return of the aneurism, and after two years and a half it is unlikely that any recurrence will take place.

In this connection it is interesting to refer to a case of popliteal aneurism reported by J. Goyanes,[10] of Madrid, in which he ligated the artery above and below the sac, and then transplanted a section of the popliteal vein to bridge the defect in the artery. The result was successful. This operation was suggested by San Martin in 1902, and this is the first clinical case. The anastomosis was made according to the technique of Carrell. It is impossible to say what the future of this operation will be, but it certainly is of limited applicability and requires the most expert handicraft. It is unlikely that one who has not done considerable experimentation with arterial suture would be justified in attempting it, especially

when the Matas operation is so much simpler and gives such remarkably good results.

In a ruptured aneurism with a large false sac, such as was found in my second case, it is difficult to carry out completely the Matas technique. The lining membrane has not yet taken on the characteristics of the intima of the vessel, nor is it sufficiently organized to stand the necessary traction by the sutures to permit of obliteration. Even in these cases, however, the openings of the vessels in the sac can be closed by suture and the principal benefit of the Matas operation gained, namely, the cure of the aneurism with the least possible interference with the circulation of the part.

The great disadvantage of the older operations is the extent to which they interfere with the circulation of the part beyond the aneurism, and the consequent frequency of gangrene. The ligation operation not only interferes with the circulation in the sac, but also cuts off a certain number of anastomotic branches which originate between the ligatures and the sac. The extirpation operation, although it allows the ligatures to be applied much nearer the sac, also greatly interferes with the establishment of anastomotic circulation by injury of the surrounding tissue, and gangrene frequently follows.

The Antyllian operation, although not cutting off as many anastomotic branches as the ligation or extirpation operations, at the same time does require considerable manipulation beyond the sac in order to apply the ligatures and consequently is objectionable. To my mind, the Matas operation is the simplest yet devised, and the least likely to be followed by gangrene. That it is curative the statistics show conclusively.

The following is an account of my second case:

Dr. F., aged 57 years, was operated upon at the Bryn Mawr Hospital, on November 24, 1906. I first saw the patient on October 30th with Dr. Walter Chrystie. At that time he had a small popliteal aneurism about the size of a hen's egg. He had been having some fever and was generally in very bad con-

dition. His urine contained albumin and casts and the secretion was scanty. His vessels were atheromatous and he had valvular heart disease. At this time he was put on increasing doses of iodide. I next saw him on November 13th with Drs. Earnshaw and Gamble. His general condition had not improved, excepting that the kidney secretion was greater. Two days before operation his pulse was 120 and of very high tension. The leg was very much swollen, which had developed since I first saw him. The pain had been so great since the increase in the size of the aneurism that morphia had to be used pretty continuously. On account of his general condition I was very loathe to operate upon him, but he suffered so much that there seemed to be nothing else to do. He had gotten up to 75 grains of iodide a day. Half an hour before operation he was given 1-6 of a grain of morphine and 1-100 of a grain of scopolamine. A tourniquet was applied until the pulsation ceased, and I then injected the line of incision with Schleich fluid. I made an incision, opened and evacuated the aneursmal sac without causing much pain. The aneurism had ruptured and a false sac had been formed in the surrounding tissues. The removal of the organized portion of the clot caused considerable pain, and as I was unable to detect with my finger the arterial openings in the sac, and if I had found them, would have been unable to suture them because any attempt to put the patient's leg straight gave him a great deal of pain, I was compelled to give him ether. I found both openings in the sac and closed them by suture. The sac was very friable and the sutures cut very easily, so that I had considerable difficulty in closing the openings, especially the proximal one. The sac wall was so friable that I could not reef it over, as is done in the Matas operation, and I therefore simply introduced a gauze pack and a few sutures in the muscular structures. The patient stood the operation, which occupied forty-five minutes, very well.

The next day he was passing a sufficient quantity of urine, his pulse had dropped to 104, and was of much lower tension. The swelling of the leg had greatly decreased, he had practically no pain, and his temperature was normal. The circulation in the foot was good, though no pulsation could be felt in the anterior tibial. This pulse could not be detected before the operation. This improvement in the patient's condition was only

temporary, however, as the kidney and heart lesions steadily progressed until January 22, 1907, when he died of uræmia. At the time of his death there was no œdema or other recurrence of the aneurism. The wound had gradually filled up with granulation, until there was only a superficial area unhealed.

The only advantage of the operation in this case was that the patient was completely relieved of his pain and was able for a while to get out of bed with comparative comfort.

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THE SUTURE OF BLOOD VESSELS. IMPLANTATION AND TRANSPLANTATION OF VESSELS AND ORGANS. AN HISTORICAL AND EXPERIMENTAL STUDY.*

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It is only in comparatively recent years that conservative methods have been employed in dealing with the larger blood vessels in the human body. This advance is in a large measure due to the results obtained by the application of modern surgical technic to animal experimentation.

The ligature, which during the middle ages waged a constant warfare with cauterization, compression and other methods of hæmostasis, was toward the end of the eighteenth century recognized as the best method for controlling hemorrhage from large and small blood vessels. Inasmuch as ligation of the large vessels not infrequently gave rise to gangrene and sometimes caused loss of life, this method was not an ideal one. Some years elapsed, however, before further progress was made; then surgeons began to apply the lateral ligature in partial wounds of veins where the continuity of the vessel was not interrupted. This method was first used successfully about the beginning of the nineteenth century, but, as was the case in other branches of surgery, first came into general use after the introduction of antiseptics. The lateral ligature has the disadvantage that it can be used in only a limited number of cases, for if the wound in the vessel is

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* From the Hunterian Laboratory of Experimental Medicine, The Johns Hopkins University. This paper in full, with details of the experiment protocols and an exhaustive list of references to literature, was published in *The Johns Hopkins Hospital Bulletin,* May, 1907.

large the ligature will produce considerable narrowing of its lumen and there is danger of the ligature slipping. To meet these difficulties various clamps were devised for approximating the edges of venous wounds during the process of healing, but the great objection to this method, although it was a step in the right direction, was that it prevented primary healing of the cutaneous wound.

The Lateral Suture of Veins and Arteries.

The problem was solved by the introduction of the venous suture, which was carried out for the first time successfully by Schede in 1882. This method was later employed in numerous cases and has now come into such general use that almost every surgeon of experience has had occasion to use it.

The beginning of a conservative treatment of arterial wounds antedates by more than a century the first experiments with the lateral suture of veins. In 1759 Hallowel, an English surgeon, at the suggestion of Lambert, who had observed the spontaneous healing of vessel wounds after venesection, sutured an artery in man for the first time. A small wound in the brachial artery was closed by placing a pin through the lips of the wound and passing a thread around it. The patient recovered and the radial pulse remained nearly as strong as that in the other arm.

In 1772 the question of arterial suture was tested experimentally by Asman, who closed wounds in the femoral arteries of four dogs by the same method which Hallowell had employed in man. None of these experiments were successful, and Asman therefore declared the method insecure and dangerous. It was not until 1881, after antisepsis had gained a firm foothold, that arterial suture was again tried in animals, but without the desired result. In 19 cases Gluck sutured longitudinal wounds in the common iliac arteries of large dogs and in the aorta of rabbits, but there was always hemorrhage from the stitch holes and in tying the sutures tears were often made in the vessel wall. To overcome these difficulties he later constructed small ivory clamps, with which the wound in

the artery was closed and which were allowed to remain in situ. In this manner he succeeded in closing a partial wound of an artery with preservation of its lumen. Several years later v. Horoch experimented with arterial suture, but, likewise, with little success.

To Jassinowsky, who published the results of his experiments in 1889 in his inaugural dissertation, belongs the credit of having proven conclusively that arterial wounds can be sutured with preservation of the lumen of the vessel. He avoided the femoral artery, which had been used by previous experimenters, and used the carotids of large dogs, horses, and calves, making longitudinal and transverse wounds in the vessels and then suturing them. The longitudinal wounds varied in length from 3 mm. to 2 cm. and the transverse wounds included ⅓ to ½ of the circumference of the vessel. Of 26 experiments, all were successful except four, and in none of the successful cases was there secondary hemorrhage, thrombosis or aneurysm formation, although some of the specimens were examined as late as a hundred days after the operation.

Jassinowsky attributed his good results to his technic and to the fact that he experimented upon vessels of large caliber. He used fine curved needles and fine silk, the interrupted sutures being placed about 1 mm. apart, including only the media and adventitia and avoiding the intima. As a result of his experiments he reached the following conclusions: (a) The arterial suture heals by first intention; (b) bleeding after operation can be surely and completely avoided; (c) secondary hemorrhage and thrombosis are not to be feared; (d) suture should be done in all recent, clean longitudinal, oblique, and flap wounds of large vessels and in transverse wounds not exceeding one-half the circumference of the vessel; (e) the strictest asepsis is necessary; (f) the suture is easily done.

Murphy in 1897 published the results of numerous experiments with the partial suture of arteries along with other experiments with the resection of arteries.[2] He sutured 11 partial wounds in the abdominal aorta,

[2] Vid. infra.

carotid, femoral and iliac arteries of dogs and two wounds in the carotids of sheep. These were longitudinal and oblique wounds ¼ to ⅝ inch in length and transverse wounds including ⅓ of the circumference of the vessel. Of the 13 sutures 6 were entirely successful, the lumen of the vessels being preserved. In 10 cases a continuous suture of fine silk, including all the coats of the vessel, was used; in one, interrupted silk sutures were used, and in two, kangaroo tendon was the suture material. As the means of provisional hæmostasis Billroth clamps armed with rubber were usually used, sometimes a heavy silk thread twisted and held with the fingers.

As a result of his own and the experiments of others Murphy came to the following conclusions: (a) Besides the most careful asepis, a good technic is necessary for the success of vessel suture; (b) the vessel must be exposed very carefully and a good means of provisional hæmostasis applied; (c) the edges of the wounds must be accurately approximated and bleeding completely stopped; (d) as suture material he recommends silk which should include only the outer coats of the vessel; (e) he recommends the suture of the vessel sheaths and surrounding tissues as a support to the vessel suture.

In 1897 and 1898 SILBERBERG experimented with the arterial suture in dogs. He applied 12 longitudinal and 6 transverse sutures, 10 in the femorals, 6 in the common carotids, and 2 in the abdominal aorta. Five of the longitudinal and 3 of the transverse sutures were quite successful. For a successful suture Silberberg emphasized the importance of an absolute asepsis. As suture materials he used the finest Hagedorn intestinal needles and the finest silk. With the exception of three cases in which he used interrupted sutures, he made use of the continuous suture, which can be applied more rapidly. He does not attach much importance to the question as to whether the suture should or should not penetrate the intima, but thinks that sutures exposed in the lumen may contribute to thrombus formation. He thought a method of provisional hæmostasis, which spares the vessel wall as much as possible, was very important and made use of heavy silk threads which were passed around the vessel and, after being twisted, were held thus by means of clamps. The slight bleeding from the stitch holes is easily stopped by a little compression. As an additional support he recommends the suture of the vessel sheath. Concerning the indications for vessel suture this author says: (a) The wound should be clean; (b) only large vessels, such as the aorta, the carotid, subclavian, axillary and femoral vessels, should be sutured; (c) longitudinal oblique, and transverse wounds, which do not exceed one-third of the circumference of the vessel are adapted to suture.

In 1899 DÖRFLER published a very interesting and instructive paper, describing the results of his experiments with the suture of arteries. Altogether there were 20 experiments, 16 being simple sutures of longitudinal, oblique and transverse arterial wounds with 12 successful results and 4 being sutures of completely divided arteries, which will be described later.[3] As the result of his experiments, Dörfler came to the following

[3] Vid. infra.

conclusions: (a) Arterial suture is only indicated in clean wounds; (b) for temporary hæmostasis the best means are compression with the fingers, strips of gauze twisted together, or clamps armed with rubber; (c) fine needles and a continuous suture of fine silk including all the coats of the vessel should be used; (d) slight pressure upon the suture for a few minutes after its completion will readily stop bleeding; (e) the vessel sheath should also be sutured.

JAKOBSTHAL, who examined Dörfler's specimens histologically, found that the process of healing of arterial wounds proceeds as follows: The incision becomes filled with blood and fibrin, there being only slight deposits within the lumen about the suture and upon the inner aspect of the vessel wound. These deposits are very early, even in the first few days, covered with endothelium. Soon there is an active formation of new connective tissue and blood vessels in the adventitia and to a lesser extent in the media. These make their way into the clot and in a certain measure organize it, thus forming an end-, mes-, and peri-arteritic growth rich in cells. Then there is a retrogressive process; the cells become fewer and less rich in protoplasm, while a fibrous substance appears between them. This substance in the media and adventitia is chiefly connective tissue with a few elastic elements, while in the intima there is an extraordinarily rich new formation of fine elastic lamellæ and fibers which may lead to the formation of a kind of secondary elastica, at least in the region of the scar.

In 1906 DORRANCE published a method of vessel suture, which he claimed to be original with him, but which is almost identical with that described by Clermont in 1901. Dorrance used a continuous mattress suture of fine Pagenstecker's thread with the dropping-back one-half a suture length every third suture, continuing the same suture as a whip-stitch over the everted edges of the artery after completing the mattress suture. With this method he experimented with the closure of wounds in arteries and the union of completely divided arteries.

There were 14 operations in all, nine on horses and five on dogs, and of the 14 wounds 12 suppurated. There were three complete circular and 11 partial transverse, oblique and longitudinal wounds. Ten of the vessels were examined from 2 to 14 days, and the other four from 21 to 42 days after the operation. In seven no thrombus was visible, in five a small mural thrombus was present and in two complete thrombosis. These are remarkably good results considering the number of suppurations. I am inclined to think that, had the specimens been examined at longer intervals after operation, more complete thromboses would have been present, especially when we consider the number of cases in which mural thrombi occurred.

While animal experimentation has shown conclusively that arterial wounds can be sutured successfully, numerous instances of successful suture of accidental wounds of arteries in man have demonstrated the practical value of this pro-

cedure. Such cases have been reported by Heidenhain, Israel, Ssabanejew, Orlow, Lindner, Garré, Seggel, Veau, Heinlein, Baum, Torrence, and others. Up to July, 1902, Schmitz was able to collect 21 cases of lateral sutures of arteries in man, the axillary artery having been sutured seven times, the femoral five times, the popliteal and brachial each three times, the common iliac, common carotid, and internal carotid each once. In 1903 Höpfner collected 30 such cases.

The results of the foregoing experiments on animals and the clinical experience show that for a successful suture the following things are necessary: (a) A very perfect aseptic technic; (b) clean cut wound edges which can be approximated without too much tension; (c) very careful handling of the vessel without stripping its sheath too much.

While there is considerable difference of opinion as to whether silk or catgut is the best suture material, there is little doubt that the former is preferable. It can be obtained in finer sizes, handled much more easily, and sterilized more surely. The needles should be as fine as possible, but whether straight or curved depends upon the location of the vessel to be sutured.

The question as to whether the interrupted or continuous suture should be used, seems to be settled in favor of the latter, which is simpler and can be applied more rapidly. The question as to whether the suture should penetrate all the coats of the vessel or avoid the intima, seems of more importance. While Jassinowsky and others recommend the avoidance of the intima, v. Horoch, Murphy, Dörfler, Dorrance, and others allow their sutures to penetrate the intima, in fact, in suturing veins it is almost impossible to avoid it. By including all the vessel coats the suture is not only simplified, but made more secure.

Various methods have been used for producing temporary hæmostasis, finger pressure, various clamps, strips of gauze, etc. The main desideratum is to injure the vessel wall as little as possible. The pressure of the fingers is the gentlest method and should be used in man, where possible.

If there is leakage at the site of suture a slight compression will generally cause it to cease in a few minutes.

The Circular Suture of Arteries and Veins.

Inasmuch as the lateral suture was not successful in large transverse wounds of vessels and in cases where the edges of the wound were crushed or otherwise injured, attempts were made in such cases after resection of the vessels, and in complete transverse wounds of vessels, to unite the ends of the vessels, by the simple circular suture, by protheses of various kinds or by invaginating one end into the other.

The circular suture of arteries.—The first experiments of this nature were those of Robert Abbe of New York, who published his results in 1894.

Abbe divided the femoral artery of a dog and united it again by tying the ends together over a small hourglass-shaped tube of thin glass. The immediate result of the operation was very favorable, for the circulation of the leg was re-established as soon as the clamps were removed and the dog recovered promptly. After some time the artery was removed and examined. The tube was found lying free in the lumen of the vessel which had become occluded a short distance below it. Abbe united the divided aorta of a cat in a similar manner and afterwards exhibited the animal, thinking that its survival demonstrated the patency of the aorta. This vessel, however, might have become gradually occluded without inconvenience to the animal.

In 1896 Briau and Jaboulay made ten experiments with the circular suture of carotid arteries in dogs, the ends of the vessels being united with U-shaped sutures, which everted the edges and approximated intima to intima. None of the experiments were successful, all of the vessels becoming thrombosed. They later tried the method on a larger vessel, namely the carotid of a donkey, with perfect success. This method was tried in 1900 by Salomoni, who claimed the honor of discovering it.

Murphy in 1897 published a very interesting and important article in which he detailed his numerous experiments with the suture of arteries and described a new method for the union of completely divided vessels. This method, which is said to give a more solid union than the simple suture, consists in invaginating one end of the vessel a short distance into the other and is done in the following way: After applying Billroth clamps armed with rubber, the artery is divided and the proximal end is invaginated into the distal by means of three or four double-needled silk sutures which include only the adventitia and media of the proximal end, but are passed through the entire thickness of the distal end. When these

sutures are drawn up and tied the ends are easily invaginated and fastened in this position. After the invagination is completed, the free edge of the distal end is sutured to the proximal by several interrupted sutures which include only the adventitia and media of the proximal end, but the entire thickness of the distal. The invagination is sometimes facilitated by splitting the distal stump longitudinally for a short distance.

This method was tried on the carotids of dogs three times, on the carotids of calves four times and on the carotids of sheep four times, once on the femoral artery and abdominal aorta of dogs. Only three of these cases were successful, thrombosis occurring in the others. The unfavorable results were thought to be due in a large measure to the small caliber of the vessels which were used.

Murphy also made a few experiments with the simple suture of arteries, the carotids of sheep being sutured twice, the carotids of dogs and calves once each and the abdominal aorta of a dog once. The continuous suture was used four times and the interrupted suture once. Only one of the five experiments was successful.

The invagination method was tried by DÖRFLER four times, twice in the carotids and twice in the femorals of dogs. In three cases thrombosis occurred; in the other case the lumen was unobstructed when the animal died of a venous hæmorrhage only three days after the operation.

In discussing Murphy's paper at the International Medical Congress in Moscow in 1897 NITZE demonstrated some small ivory protheses, resembling those later described by Payr. They consist of small ivory cylinders over which the ends of the vessel are slipped in such a way as to approximate intima to intima. A simple ligature holds them in this position.

In 1898 GLUCK, who had done pioneer work with the lateral suture of arteries, described a new method of circular suture. After exposing the artery and applying clamps armed with rubber, a small section of the artery was excised and slipped over one of the ends in the manner of a cuff; the ends of the vessel were sutured together with interrupted sutures which included only the adventitia and media, and then the resected portion was drawn over the line of suture and fastened thus with a few stitches. Instead of using a section of the artery to be sutured, rings of rubber and decalcified bone or a section of vessel from the same or another animal can be used.

PAYR, fearing that a simple circular suture could not withstand the pressure within large arteries devised a method, which he published in 1900, of uniting divided vessels by invaginating the ends over extra-vasal protheses of magnesium, which is absorbable in the body. If the vessel is an artery, the central end is invaginated into the peripheral, if a vein, the peripheral end is invaginated into the central. The protheses consist of hollow cylinders of magnesium, which have very thin walls and vary from .3 to 1 cm. in length. On the outer surface of the cylinder, near one end, there is a small groove, one-third to two-thirds of a millimeter deep, in which the ligature is placed. The method, as applied to arteries, is carried out as follows: After provisional closure and division of the artery, the

central end is drawn through the cylinder, which just fits over the vessel, by means of three sutures placed in the end of the vessel, which, after being drawn through the cylinder, is everted over it and fastened thus with a ligature of fine silk. The peripheral end is then drawn over the everted cuff and also fastened with a ligature, broad surfaces of endothelium being thus approximated. Payr thinks the fact that the prothesis is absorbable is of great importance. This property of the prothesis is probably of very little importance, for it requires from two to four weeks, or even longer, to be completely absorbed.

Payr, who tried the method on the carotids of dogs and pigs, says it can be done very easily and quickly and claims to have obtained very good results with it; however he does not state how many experiments he has made and makes no reference to any journal of experiments. The article is illustrated with schematic drawings, all of his preparations having been destroyed in a fire.

In an article published in 1904 Payr, on the strength of the experiments of others with it, notably those of Höpfner, champions his method and says the unsuccessful experiments of Salinari and Virdia, Jensen, and Reinsholm were due to the fact that they did not proceed according to his directions.

In 1901 BOUGLÉ performed a few experiments with circular suture of the carotids of dogs. He first used the method of Murphy, invaginating the ends by means of U-shaped sutures. The vessels, however, were so small that obliteration of the lumen always occurred. He then tried a new method, invaginating the ends only a few mm. and fastening them thus by interrupted sutures, which included only the media and adventitia. He mentions one case, in which both carotids were sutured, one by this method, the other by simple end to end union with interrupted sutures which did not include the intima. When examined 15 days after operation both vessels were patent, the intima was smooth and no clots were present.

In 1902 articles upon the circular suture of arteries by Salvia, Salinari and Virdia, Carrel, Thomaselli, and others appeared.

SALVIA made numerous experiments upon the femorals of dogs and the carotids of donkeys and sheep with special reference to the process of healing in wounds of arteries. He employed the end to end suture with fine silk, after resecting considerable lengths of the vessels. In none of the cases did the lumen remain patent. He examined the specimens histologically and found that, with the exception of the elastic fibers, there was a complete restitution of the vessel wall.

The object of the experiments of SALINARI and VIRDIA was: (a) To test the methods most often tried in animals and man and from the results to determine which offers the best chance of restoring the function of the vessel; (b) to investigate the healing process microscopically and see whether the arterial walls will be sufficiently strong at the sutured point. The experiments, about 30 in number, were done on large dogs, the carotid and femoral arteries being generally used, the abdominal aorta being used twice. With the exception of a few partial transverse and

longitudinal sutures, the sutures were done on completely divided arteries. For provisional hæmostasis various clamps were used, but, finding these unsatisfactory, they constructed a special clamp with parallel blades, regulated by a thumb screw, which proved very satisfactory.

Of 16 sutures done according to Murphy's method, six became infected and the results were negative, six healed with mural or canalized thrombi; in two the lumen remained pervious, though considerably narrowed, and in two others the site of suture presented an almost normal appearance. The protheses of Payr were tried three times, two of the animals died of infection, the other of secondary hæmorrhage.

The authors conclude that suture is preferable to ligation in wounds of large size and that in cases of complete transverse wounds invagination is the best method, although their results would hardly justify these conclusions. In cases of *restitutio ad integrum* the vessel wall is richer in muscle cells and elastic fibers than under normal conditions.

THOMASELLI emphasized the importance of approximating intima to intima. In his experiments, which were done on the abdominal aorta, carotid and femoral arteries of 11 dogs and the femoral artery of one goat, the endothelial surfaces were held approximated by fine clamps, which were removed in turn as the suture proceeded. Interrupted sutures, passing through all the coats of the vessel were used and the suture matrials were fine curved needles and silk thread. In seven cases there were positive results with or without narrowing of the lumen, in three the results were negative and in two others it was necessary to ligate on account of sclerosis of the vessel wall.

In an article published a year later Thomaselli says, that the best method of vessel suture is that previously recommended by Salomoni, which consists in approximating intima to intima by means of U-shaped sutures transfixing the entire wall of the vessel. He studied the process of healing in transverse wounds to determine whether there is a real *restitutio ad integrum* as Burci had already observed in the case of longitudinal wounds. Histological examination showed the following: (a) The muscular layer is completely regenerated; (b) the elastic fibers of this layer are regenerated and are more numerous at the edges of the scar and near the lumen where they do not form a real inner elastic membrane, but they replace this membrane and prevent the formation of an aneurysm; (c) neither the inner elastic membrane nor the elastic fibers of the adventitia are reformed, the latter being composed of fibrous connective tissue; (d) close up to the suture one can demonstrate the complete restoration of the three layers with hypertrophy of the muscle cells and elastic fibers.

In 1902 CARREL published a method of circular suture, which, while differing very little from certain methods previously employed, has greatly facilitated such sutures. The ends of the vessel to be sutured are first united by three tension sutures of fine silk, inserted at equidistant points on its circumference. Traction upon these sutures approximates the edges of the vessel and renders the application of a continuous suture comparatively easy. In his original communication Carrel recommended

avoiding the intima, where possible, but in his later experiments the sutures have included the entire thickness of the vessel wall. He has made no systematic study of the circular suture of divided arteries and veins but by applying his method to arterio-venous anastomoses and the transplantation of vessels and organs has obtained brilliant results.[4]

In 1903 an article by JENSEN on the circular suture of blood vessels, which was awarded a gold medal by the University of Copenhagen, was published. In this very complete and interesting article Jensen describes the various methods for uniting completely divided vessels which had been used up to that time and gives a critical review of the results obtained with them. Jensen's own experiments in which bone protheses, the magnesium protheses of Payr, and the various suture methods were tried on the vessels—mostly the internal jugular veins and carotid arteries—of horses and goats, were undertaken with a view to solving the following questions: (a) Why does thrombosis occur so often? (b) in how far does this or that method offer a better guarantee against thrombus formation.

Of three arteries united by Murphy's method two became completely thrombosed and one remained unobstructed; of three united by invagination over protheses of bone, in two the lumen was much narrowed and in the other almost obliterated; of twelve united by sutures seven were thrombosed, three were more or less constricted, and two were neither thrombosed nor constricted.

Ten veins were united by various protheses; of these eight became completely occluded and two remained patent but partly occluded. Seven veins were united by sutures; of these four were thrombosed, two more or less constricted and one neither thrombosed nor constricted.

From these results which are not very encouraging, Jensen rejects protheses and concludes that the best method of uniting completely divided vessels is to insert two or three simple interrupted or U-shaped sutures and join them by continuous sutures. He prefers silk to catgut and allows the suture to include the entire thickness of the vessel wall. He thinks thrombosis is due chiefly to infection with pathogenic organisms and says, "If we accept infection as the only cause of thrombus formation we have the best explanation of the capriciousness of the results of the experiments. This agrees also with the fact that sutures not involving the intima are more likely to succeed for infection of the lumen is more difficult if the suture does not enter it."

In an extensive article published in 1903 HÖPFNER gives statistics of the results of the ligation of large arteries and veins in man and thus points out the need of a practical method for uniting completely divided vessels. He then gives a history of the lateral and circular suture of vessels in animals and man. He experimented with the circular suture of vessels, vessel implantation and transplantation, and the replantation of amputated extremities, using the magnesium protheses of Payr.

Of six arteries united by this method, two became thrombosed and

[4] Vid. infra.

four remained unobstructed, three of these being examined eight days after operation and one four weeks after operation. The experiments with transplantation and implantation of vessels and the replantation of amputated extremities will be described later.

In 1903 AMBERG experimented with the circular suture of arteries in horses and large dogs, using the carotids, femorals, and abdominal aorta. After dividing the arteries, the ends were split longitudinally for a distance of 3 to 4 mm. so that the edges could be everted after the manner of flanges which were then sutured together intima to intima. His experiments were not very successful for in only three of the six cases was the lumen entirely preserved. In one there was a mural thrombus and in the remaining two complete thrombosis and secondary hemorrhage occurred.

In 1903 DE GAETANO tried on dogs a new method for the transverse suture of arteries. He placed a small spindle-shaped glass bobbin in the lumen of the vessel and applied the suture over the bobbin which was removed when the suture was nearly completed. This is said to greatly facilitate the suture. I have not been able to consult the original article and therefore cannot give the results of the individual experiments. According to De Gaetano histological examination of the specimens four months after suture showed a complete restitution of all of the elements of the vessel wall, including the elastic fibers.

In an article published in 1903 CHÉRIE-LIGNIÈRE reviews the various methods of arterial suture and concludes that the simple suture is only applicable to longitudinal wounds and not to transverse wounds. He describes the Payr method in detail and reports his own experiments with this method. Of six cases in which the arteries of dogs and donkeys were thus united, in four the results were good, in two there was secondary hemorrhage, once due to necrosis, once to infection. The magnesium cylinders were absorbed in 20 days. Secondary hemorrhage is prevented by strict asepsis and the isolation of only a short stretch of vessel.

In 1906 DORRANCE[5] reported three cases of complete transverse suture of arteries in animals, in which he used a continuous mattress suture, whipping over the everted edges of the artery after the mattress suture was completed. In two cases the lumen remained unobstructed, in the other complete thrombosis occurred.

The circular suture of veins.—As compared with arteries very few experiments have been made with the circular suture of veins. This is probably due to the fact that the danger of gangrene following the ligation of large veins is, as a rule, less than that following the ligation of the corresponding arteries.

V. HIRSCH[6] is said to have successfully sutured the completely divided

[5] Vid. supra.

[6] Cit. by Clermont.

femoral and jugular veins of dogs in 1881. Murphy in 1897 united the divided jugular vein of a sheep by means of a continuous suture of fine silk, the lumen of the vessel being considerably narrowed by the suture. The vein was examined 28 days later and found to be occluded by adhesion at the line of suture, but no thrombus was present.

In an article published in 1901 CLERMONT gives an historical review of venous suture and reports his experiments with the lateral and circular suture of veins. The latter were limited to two sutures of the divided inferior vena cava: In one case the ends of the vessel were united by a continuous mattress suture of fine silk, which everted the edges of the vessel and approximated intima to intima; the union was completed by suturing the everted edges together with a continuous whip-stitch of the same material. The vessel was examined a month later and its lumen found to be perfectly smooth and unobstructed. In the other case he invaginated the peripheral end a few mm. into the central and fastened them thus with fine silk sutures which were allowed to enter the lumen. When examined a month later the vein was found to be patent, but greatly contracted. From these experiments and those with the lateral suture of veins, Clermont concluded that the first method is the best for suturing veins.

PAYR claims to have obtained excellent results in the union of veins by means of his magnesium protheses, which are applied to veins just as to arteries, except that with veins the peripheral is invaginated into the central end. The method is said to be more easily applied to veins than to arteries, for their walls are thinner and therefore more readily stretched. Here again Payr fails to give the number of his experiments or any exact description thereof.

In 1903 JENSEN made 17 experiments with the union of completely divided veins, using the simple suture in seven cases and protheses of various kinds in ten. Of the seven simple sutures four remained patent; of the ten cases in which protheses were used, eight became completely thrombosed and two remained patent. In six of the sutures the following method was used: After inserting two or three tension sutures, a continuous suture including the entire thickness of the vessel wall was applied. In the other case mattress sutures were used. In only two cases was catgut employed and in both thrombosis occurred. Of the ten cases in which protheses were employed, the cylindrical rings recommended by Payr were used in seven, but in only three of these were the rings made of magnesium, the others being made of bone or decalcified bone.

The circular suture of arteries and veins in man.—Cases of suture of completely divided vessels in man have been reported by Murphy, Djemil Pascha, Krause, Kümmell, Payr, Brougham, and probably others.

In 1897 MURPHY reported the following case: On September 19, 1896, a young man received a bullet wound in Scarpa's triangle just below

Poupart's ligament. When he was first seen by Murphy on October 4, there was a marked thrill and loud bruit in this region and the pulsation in the popliteal and dorsalis pedis arteries was scarcely perceptible. At the operation on October 7, a penetrating wound was found in the femoral artery, which was almost divided, and also a small wound in the femoral vein. After closing the wound in the vein the artery was resected and united by the invagination method, the central end being invaginated into the distal for about one-third of an inch. On removing the clamps there was no leakage and pulsation immediately reappeared in the artery below the anastomosis. There was no disturbance of the circulation of the leg and the patient made a good recovery.

At the International Medical Congress in Moscow in 1897 DJEMIL PASCHA reported two cases of injury of the axillary artery treated successfully by Murphy's invagination method.

KRAUSE in 1900 reported this case in which he resected both the femoral artery and vein: In operating upon a woman, 55 years of age, for a carcinoma, the femoral vessels were found to be involved to such an extent that it was necessary to resect a portion of them. With the leg strongly flexed the ends of the vessels were then invaginated and fastened thus with sutures which did not involve the intima. Immediately after the operation pulsation could be felt in the artery distal to the suture; the leg had to be amputated later on account of gangrene.

In 1900 KÜMMELL reported two cases, in one of which he anastomosed the femoral artery, in the other the femoral vein. In removing a carcinoma of the glands of the groin the femoral artery was found to be involved to such an extent that it was necessary to resect 5 cm. of this vessel. This was done in the following manner: After freeing the vessel above and below and applying clamps armed with rubber, the diseased portion was removed and, with the leg flexed at the hip, the central end of the vessel was invaginated ½ cm. into the distal and sutured with fine silk which did not include the intima. This suture was reinforced by a second layer of sutures which included only the adventitia. After a short time distinct pulsation could be felt in the popliteal artery. The carcinoma recurred in a few weeks and death followed in four months; at the autopsy, unfortunately, nothing could be seen of the suture, for the vessel was completely destroyed by the growth.

In the second case it was necessary to resect 2 cm. of the femoral vein, likewise on account of involvement in malignant growth. The ends of the vein were united by means of a continuous suture of fine silk which doubtless penetrated the intima. After removing the clamps the circulation in the leg was re-established, and the patient made a good recovery.

In 1901 PAYR had an opportunity to try his method in man: In extirpating carcinomatous glands of the groin 4.5 cm. of the femoral vein was removed on account of involvement in the growth. The ends of the vessel were united by invagination over a magnesium prothesis after his method. The patient died three days later of pneumonia and examination showed that the lumen of the vein was fully preserved.

In 1906 BROUGHAM reported the following case: A man, 39 years

of age, received a stab wound which almost completely divided the axillary artery and vein. The vein was ligated, but the division of the artery was completed, and the ends united by invagination after Murphy's method. The patient made an uneventful recovery.

Remarks.—What has been said above, in discussing the lateral suture of vessels, regarding suture materials, the means of provisional hæmostasis, the question as to whether the suture should or should not penetrate the intima, the need of a perfect aseptic technic, etc., applies equally well to the circular suture.

The methods recommended for uniting completely severed vessels may in general be divided in two classes: (a) Those in which the simple suture is used; (b) those in which mechanical aids are employed.

The suture has been applied in various forms; some have used simple interrupted sutures and mattress sutures, others the continuous suture; some include all the coats of the vessel in the suture, others try to avoid the intima, which in veins is almost an impossibility. Murphy recommends uniting completely divided vessels by invaginating one end a short distance into the other and fixing them thus with sutures.

The mechanical aids may be divided into the extra-vasal and endo-vasal. Among the former may be mentioned various clamps, decalcified bone and ivory rings, sheaths made of sections of other arteries or veins, aluminum rings, magnesium rings, etc. The most important of these are the magnesium rings or protheses of Payr, by means of which the ends of the vessel are so invaginated that intima is approximated to intima. Among the endo-vasal aids we may mention the glass cylinders of Abbe and Gluck, the caramel cylinders of Carrel and the glass bobbins of De Gaetano. These are of no importance clinically, but are of historical interest.

Although the results of the application of the invagination methods of Murphy and Payr to vessels in man have proven very gratifying, I cannot but feel in the light of the animal experiments of Carrel, Jensen, myself, and others, that the simple suture is preferable to these more complicated pro-

cedures. The results obtained in animals by Carrel and myself have been, barring the cases in which infection occurred, almost ideal and seem to demonstrate conclusively that the sutures can penetrate the intima with impunity. The method is simple, easy, and requires no mechanical aid. It seems to me that, just as in intestinal suture we approximate endothelium to endothelium, so in blood vessel suture it is advisable to approximate intima to intima. With Carrel's method traction upon the three primary sutures, during the application of the continuous suture, approximates intima to intima more or less accurately, but the apposition might be improved by substituting U-shaped sutures for the single traction sutures and then applying the continuous suture to the everted edges, as has been suggested by Jensen. The advantages obtained by this method might, however, except with large vessels, be counterbalanced by the constriction produced.

Arterio-Venous Anastomoses.

Circular or end-to-end arterio-venous anastomosis.—The first successful arterio-venous anastomosis was performed by Gluck who united the carotid artery of a dog to the jugular vein by circular suture without thrombus formation. In 1902 Berard and Carrel divided the femoral artery in Scarpa's triangle and sutured the central end of the artery to the peripheral end of the saphenous vein. The anastomosis withstood the arterial pressure and the vein became distended and pulsated actively, but no physiological results were observed, as the animal died of infection two days after the operation. In the same year these experiments were continued by Carrel and Morel, who succeeded in anastomosing the central end of the carotid artery into the peripheral end of the external jugular vein without subsequent thrombus formation. Several weeks after the operation, when the animal was presented before the "Société nationale de médecine," the external jugular vein pulsated actively and a loud systolic murmur could be heard at the point of anastomosis. During the several months the animal was under observation the results remained satisfactory.

In 1902 San Martin y Satrustegui also experimented with the circular arterio-venous anastomosis. He made a series of experiments on dogs, operating by preference in the groin, but also in the neck and other regions traversed by large blood-vessels. The femoral vessels were separated and the central portion of the femoral vein ligated. Forceps were then applied to the central portion of the artery and the distal portion of the vein and the vessels divided; there was no bleeding from the distal end of the artery, although it was not clamped or otherwise occluded. The central end of the artery was then united to the distal end of the

vein by invaginating the artery into the vein and suturing them with catgut. On removing the clamps the arterial blood flowed into the vein and the distal portion of the artery, which had remained bloodless during the operation, in 30 to 60 seconds after the current was turned on, began to carry fluid which looked like a mixture of arterial and venous blood as though the current had been reversed. This end of the artery was then ligated, the wound closed, and the animal allowed to live. In later cases St. Martin saw the saphenous vein fill and change color as soon as the arterial blood was turned into the femoral vein.

All of the animals stood the operation well, except those whose peritoneum was invaded. One of the more vigorous dogs lived eight days with anastomosis of the carotid artery and jugular vein on both sides, death being due to hemorrhage, or asphyxiation from enormous œdema of the neck. Few of the dogs had œdema, but in many there was a hemorrhage on the eighth day, which was often fatal. As to the cutaneous wound, it healed usually by first intention, sometimes there was a little suppuration, and in two or three cases a real phlegmon. The specimens were examined at periods varying from 48 hours to 20 days after the operation. The vessels were found completely obliterated by extensive thrombi, which, in the late examinations, were already organized. In one case the vessel remained pervious for two days, but in some instances coagulation took place even before the current was turned on.

In 1903 EXNER undertook certain experiments with the intention of studying the changes which veins undergo, under arterial blood pressure. In four dogs he united the central end of the carotid artery to the peripheral end of the external jugular vein by means of the magnesium protheses of Payr. The wounds healed without reaction, but when examined two to six weeks after the operation, the vessels were found to be completely thrombosed. HÖPFNER in 1903 also experimented with arterio-venous anastomoses, using the protheses of Payr. In all of his cases there was thrombus formation which he attributed to degeneration of the thin vein wall, produced by the high arterial tension.

In 1905 the experiments begun in France by Carrel and Morel were continued in this country by CARREL and GUTHRIE, and, with improved technic, various arterio-venous anastomoses were done with very successful and interesting results. The technic is thus described by Carrel: "The threads and needles were the finest and strongest obtainable. The threads were sterilized in vaseline and applied when heavily coated with the same. The vessels were handled very gently and the endothelium was protected from drying by isotonic sodium chloride solution or by sterilized vaseline. No dangerous metallic forceps were used. The greatest care was exercised to obtain accurate and smooth approximation of the endothelium of the vessels. Finally, we developed a technic which is equally well adapted for arterio-arterial, veno-venous or arterio-venous anastomoses, and which yields uniformly successful results."

Circular or end-to-end arterio-venous anastomoses may be divided in two classes; viz., (a) uniterminal, and (b) biter-

minal arterio-venous anastomoses. The former will be discussed now, but the latter will be considered when we describe the implantation and transplantation of arteries and veins.

Concerning uniterminal anastomoses Carrel and Guthrie write as follows: "The termino-terminal anastomosis may be performed in nearly all cases even when the size of the vessels differs greatly. An artery may be easily united to a vein of twice its caliber. On the contrary, it is more difficult to unite a small vein to a large artery, for the venous wall is easily folded, while the artery on account of its thick walls is not. The more nearly similar the diameter of the vessels, the more easily successful anastomosis may be performed. When the vein is much larger than the artery and the consequent foldings of the vein in making the anastomosis are irregular, as may happen if the operation is performed without sufficient care, hæmorrhage occurs at the line of union. Fibrin may be deposited in the bottom of the foldings and in the miniature gaps occurring between the endothelial coats of the artery and vein. Therefore, when the difference in size of the artery and vein is too great, instead of end-to-end anastomosis, it is better to perform lateral implantation of the end of the vein into the wall of the artery.

"This termino-lateral arterio-venous anastomosis is more difficult than the former. It should be used only when the end-to-end anastomosis seems inadvisable, owing to the difference in size of the vessels or when the experimental result sought for indicates it. For instance, when a segment of intestine is transplanted into the neck for the purpose of establishing communication between the cut ends of the œsophagus, the end-to-end anastomosis of the intestinal vein to the jugular vein is impracticable, owing to the enormous difference in the size of the vessels. It then becomes necessary to make a lateral implantation of the end of the small vessel on the wall of the jugular vein. Or this lateral implantation is performed in order to obtain certain modifications of circulation, as, for example, lateral implantation of the central end of the external jugular vein on the common carotid artery, in order to diminish the amount of blood in the peripheral portion of the artery.

"Although the termino-lateral anastomosis is somewhat more difficult than the end-to-end anastomosis, it is by no means impracticable on this account. By making a triangular opening larger than the lumen of the vein, through the wall of the artery, and taking care to have an accurate approximation of the endothelial surfaces of the vessels, the anastomosis is very satisfactory, as absolutely no blood escapes and no stenosis of the vein is produced.

"A third kind of anastomosis, more rarely used than the kinds above described, may also be mentioned. When the vein is exceedingly small, so small that a direct anastomosis is impossible, it is dissected a far as its junction with a larger vein. The wall of this vein around the mouth of the small vessel is then resected and grafted onto the wall of the artery.

"As previously stated this paper will deal mainly with the transplantation of veins onto arteries.

"There are six possible varieties of this operation, as the central end or the peripheral end of the vein may be united to the central end, the peripheral end or the wall of the artery. But as the anastomosis of the central end of the artery to the central end of the vein is practically the same in result as lateral implantation of the artery onto a vein, and as anastomosis of the peripheral end of the vein to the wall of the artery produces practically the same results as the anastomosis of the peripheral end of the vein to the central end of the artery, they do not deserve special mention. Four varieties only will therefore be described.

"1. *Union of the central end of the vein to the peripheral end of the artery.*—Anastomosis of the central end of the external jugular vein to the peripheral end of the common carotid artery is an example of this kind of operation. It produces a vessel composed in its upper portion of the carotid artery and in its lower portion of the external jugular vein. The pressure in this portion of the artery becomes lower than the normal blood pressure and the direction of the blood stream is reversed. The jugular carries toward the heart red, instead of dark blood. As a result, functionally, the carotid artery becomes a vein filled with red blood, being comparable in this respect to the pulmonary vein. It is probable that the wall of the artery undergoes marked anatomical changes. Owing to the lowering of the blood pressure, its wall may become thinner and the elastic and muscular layers modified, but at the present time we cannot go further into the point. But, as we have a dog in good health upon which this operation was performed nearly seven months ago, we shall subsequently be enabled to discuss it further.

"2. *Union of the central end of the vein to the wall of the artery.*—It is evident that after this operation a large part of the red blood of the artery returns toward the heart through the veins. In several cases the central end of the external jugular vein was united to the wall of the carotid artery. An abundant portion of the red blood flowed into the vein through the anastomosis with a strong thrill. The vein retained its venous functions, *i.e.*, it conveyed blood toward the heart, but was filled with arterial blood. The artery also retained its normal functions, but its blood pressure was lowered. Tracings were taken, and they showed that after the establishment of the circulation through the anastomosis, the blood pressure in the artery is markedly diminished. This result is quite natural, for the lateral implantation of the central end of the jugular onto the wall of the carotid artery permits of a kind of continuous hemorrhage from the carotid into the vein. When this operation is made on the jugular and the carotid it does not apparently alter the character of the circulation in general.

"3. *Union of the peripheral end of the vein to the peripheral end of the artery.*—This operation was performed on arteries having no, or very small collaterals. The result was the reversal of the circulation through the vein. The artery becomes filled with dark blood, venous in character. If, for instance, the peripheral end of the right renal vein be united to the peripheral end of the left renal artery, the dark blood from the right renal vein would flow through the left renal artery, the left kidney, the left renal vein and thus into the vena cava.

" 4. *Union of the peripheral end of a vein to the central end of an artery.*—It is evident that, from a functional point of view, the operation transforms the vein into an artery. Several series of experiments were performed. The external or internal jugular or the thyroid veins were united to the carotid artery; the femoral or long saphenous veins to the femoral artery; and the inferior vena cava to the aorta.

"*The transplantation of the peripheral end of the external jugular vein onto the central end of the common carotid artery.*—The right external jugular vein was exposed, thoroughly dissected and cut near the root of the neck. Its peripheral end was inserted between the sterno mastoideus and the sterno hyoideus muscles and united behind the trachea to the central end of the left carotid artery. On release of the hæmostatic clamps, the vein became filled with red blood and pulsated like an artery, it being transformed from a functional standpoint into an external carotid artery. The vein is able immediately to perform the more important arterial functions. Its wall adequately supports the increased blood pressure. Even when the carotid artery is anastomosed to a more delicate vein, such as the internal jugular or thyroid, the sudden increasing of the pressure apparently does not injure the wall. In size the vein always appears to be very much enlarged. Clinically, this operation does not produce general or local symptoms if it deals only with vessels like the carotid and the external jugular vein. Even when the central end of the carotid is anastomosed to the peripheral end of the internal jugular vein the dog manifests no abnormal symptoms. A dog on which the operation was performed three months ago is now living and appears absolutely normal in all respects."

CARREL and GUTHRIE claim to have produced an actual arteriosclerosis of an artery by suturing it into a relatively small vein. The macroscopic modifications of the artery are characterized by a slight retraction of its lumen and by a marked increase in the thickness and rigidity of its walls. The histological changes consist of an hypertrophy of the middle coat, which is due to an increase in the number and size of the muscle and elastic fibers and an hyperplasia of the interstitial connective tissue. The sclerosis of the adventitia may be regular or irregular. The same is true of the intimal sclerosis, which may present itself in the form of a regular thickening of the intima or may be much more marked in certain places than in others. The regions of greatest thickening of the intima and adventitia correspond to the places where the media is thinner. It seems that the arterial wall reacts first by an hypertrophy of the muscle layer and that the sclerosis of the intima and adventitia comes later. In a case observed three months and ten days after the operation the hypertrophy of the muscle was strongly marked, whereas, the intimal sclerosis was slight. In another case observed six months after operation the muscular hypertrophy was somewhat greater than in the preceding case, while the intimal sclerosis was much greater. No atheromatous lesions were observed.

When arterial tension is lowered by anastomosing an artery into a large vein the wall of the artery becomes thinner and its lumen larger. The muscular and elastic constituents of the medial coat diminish in number and volume.

Lateral arterio-venous anastomosis.—After his experiments with end-to-end arterio-venous anastomoses had failed, and arguing that arterio-venous aneurysms are well borne in man, San Martin y. Satrustegui in 1902 began to experiment with the lateral anastomosis of arteries and veins in goats. After opening the carotid artery and internal jugular vein in the neck, temporary hæmostasis was produced by small rubber tubing placed about the vessels at either end of the wound and openings 1 cm. long made in the vessels. The edges of the openings were then united by means of continuous sutures of fine silk, the posterior row of sutures apparently being placed from within the lumen. Two animals were thus operated upon and the result was said to be the same in both cases, though only one section was described. In this case which was examined three months after the operation, the carotid pulsated strongly and retained its original dimensions; the vein, however, was atrophied and almost empty of blood proximal to the anastomosis, but peripheral to the anastomosis was distended with dark blood and did not pulsate. The site of the anastomosis could hardly be determined by simple inspection, but seemed to correspond to the point where the vein suddenly became contracted. No opening could be demonstrated by injecting water into the vessels. Microscopic examination showed that a small opening persisted.

Arterio-venous anastomoses in man.—From these experiments, although they could scarcely be called successful, St. Martin concluded that such an operation might be of value in treating gangrene due to arterial sclerosis. He tried it clinically in two cases. The first case was a man, 52 years of age, with gangrene of the toes extending onto the metatarsus. No pulsation could be felt in the dorsalis pedis, posterior tibial or even in the popliteal artery. The femoral pulsated strongly in Scarpa's triangle. An incision was made in Scarpa's triangle and the artery easily isolated, but the vein was freed with difficulty, being rather adherent. Temporary hæmostasis was produced by rubber tubes held with clamps. Openings 8 mm. long were then made in the vessels and a fairly satisfactory anastomosis obtained. After removing the ligatures the arterial blood passed through the artery to the limb, but the vein did not change color, either because the anastomotic opening was too small or because the walls of the vein had lost the little elasticity which they normally possess. The wound was closed and the gangrenous portion of the foot removed. The immediate result of the operation was fairly satisfactory; the pains became less, either because the gangrenous portion was removed, because the nerves had been separated from the vessel sheath to which they were quite adherent, or because, thanks to the anastomosis, the leg was better nourished. Unfortunately, this condition did not continue long and symptoms appeared which required amputation of the leg through the calf. The arteries were greatly sclerosed; the vein, however, appeared normal with the exception of some atrophy, probably from disuse. St. Martin thought the veins might have assumed the function of arteries if the operation had been done earlier and been more successful. Sometime later amputation through the middle of the thigh resulted in death. The specimen showing the anastomosis was not examined, at least it is not described.

The other case was a man, 66 years old, who had gangrene of the toes. The same procedure was adopted as in the foregoing case. The artery and vein were so adherent to each other that, for hæmostasis, it was necessary to place the rubber bands about the two together. The nerve, however, was carefully separated. Very small openings were made in the artery and vein, which were united by continuous sutures. After removing the ligatures the vessels filled out, but the walls of the vein were so thick that one could not see whether arterial blood passed into the vein through the small wound. The wound in the groin was closed and the foot amputated. The patient made an uneventful recovery, but nothing is said of the subsequent behavior of the vessels.

In 1902 JABOULAY reported the following case: A man, aged 47, had senile gangrene of the right foot which required amputation, first of the foot and then of the thigh. Sometime later gangrene began in his left foot and Jaboulay performed a lateral anastomosis of the femoral vessels in Scarpa's triangle. Thrombosis, which was attributed to the presence of an arterio-sclerotic placque, occurred at the site of suture, and it became necessary to amputate through the thigh.

In 1903 GALLOIS and PINATELLLE, assistants of Jaboulay, reported this case and published the results of certain experiments, which they had made, to investigate the possibility of a reversal of the circulation in the head, arms, and legs. In order that such a reversal of circulation may take place they pointed out that the following obstacles must be overcome: (a) The valves; (b) the numerous venous anastomoses, which create short circuits and lower the blood pressure; (c) the resistance of the capillaries. Their experiments were done on the cadaver. A colored fluid was injected under pressure into the main vein of the member, but immediately returned by the other veins. After these were occluded it was impossible to force the fluid into the main vein, although considerable pressure was used. They concluded that, experimentally the circulation through the main vein of a limb, in a direction opposite to that of the normal current is prevented by the valves. They realized the fact, however, that, clinically, the valves can be forced and the current reversed in the veins, for they had observed cases of arterio-venous aneurysm, in which the veins of the limb, even at considerable distances from the aneurysm, were markedly dilated and pulsated actively.

Carrel and Guthrie, who attribute the failure of the experiments of Gallois and Pinatelle to the fact that they operated upon the cadaver and not upon living tissues, which have a great adaptive power, seem to have proven that a reversal of the circulation in a limb of a dog is possible by establishing an end-to-end arterio-venous anastomosis. An experiment on a dog showed that three hours after a *termino-terminal* anastomosis of the central end of the femoral artery to the peripheral end of the femoral vein, the veins of the thigh, the leg, and the foot were filled with red blood, and that the dark blood returned to the heart through the arteries. They found that: (a) The valves prevent, at first, the reversal of the circulation in the veins; (b) after a short time the valves gradually give way and the red blood flows through the veins as far as the capillaries; (c)

finally, it passes through the capillaries and the arteries are filled with dark blood. Probably the dark blood also returns from the capillaries toward the heart through some of the veins; (d) practically complete reversal of the circulation is established about three hours after the operation. However, when a *lateral* arterio-venous anastomosis has been done, the larger part of the arterial blood, instead of going toward the capillaries, returns to the heart through the central end of the vein and at the same time the arterial blood pressure is lowered. Experiments have shown that: (a) After a lateral arterio-venous anastomosis a very large portion of the red blood returns immediately toward the heart through the central end of the vein; (b) the peripheral portion of the vein and its branches are distended and pulsate, but the valves are not forced and the red blood does not circulate through them; (c) three hours after the operation all the valves are yet competent and no beginning of a reversal of the circulation can be detected.

If this be true very little can be expected from the treatment of senile gangrene by lateral arterio-venous anastomosis.

In 1906 HUBBARD reported the following case, in which he performed a crossed arterio-venous anastomosis of the femoral vessels for senile gangrene of the toes. The patient, a man 80 years old, was admitted to the hospital with dry gangrene of the middle toe of the right foot. There was a general arteriosclerosis and no pulsation could be felt in the dorsalis pedis of this foot. In spite of appropriate treatment the gangrene extended and involved the neighboring toes. Operation: The femoral vessels were exposed at the apex of Scarpa's triangle and a crossed arterio-venous anastomosis performed by invaginating the central end of the artery into the peripheral end of the vein and the peripheral end of the artery into the central end of the vein, and suturing them thus with fine Pagenstecher's thread. After the first anastomosis had been completed, and the means of provisional hæmostasis removed, the vein partially filled and pulsated slightly. During the manipulations the controlling tourniquet was pulled off the peripheral end of the artery and a considerable amount of dark, venous-looking blood escaped. It is hardly possible, however, that the circulation could have been reversed in such a short time. The cutaneous wound was closed with silk-worm gut and a plaster cast applied with the thigh flexed on the body to relieve tension on the vessels.

The patient made a good recovery, but the gangrene subsequently extended to the tarso-metatarsal joint, where a line of demarcation formed. At this time the author thought he was justified in making the following deductions: "Inasmuch as the circulation in the leg before operation was sufficiently poor to permit gangrene of the toes, and inasmuch as the femoral artery had been divided in Scarpa's triangle thus permitting collateral circulation only through the profunda, it was fair to suppose that very little blood would have reached the lower leg through the collateral circulation, and that the gangrene would have rapidly involved the leg unless as a result of the operation the veins were carrying arterial blood." The lower portion of the leg and foot were amputated some

time later. At this operation, which was performed without a tourniquet, the anterior and posterior tibial arteries were found to contain arterial blood, which spurted from the cut ends with fairly good force, and the veins did not appear to contain any arterial blood. These findings probably vitiate the previous deductions.

Implantation and Transplantation of Arteries and Veins.

In 1896 Briau and Jaboulay experimenting upon animals, after having removed small sections of arteries reimplanted them by circular sutures. The vessels were examined three or four days after the operation, and in all the cases occluding thrombi were present. In an article published in 1898 Gluck mentions having transplanted a portion of the jugular vein into the carotid artery of a dog. The section of vein healed in and there was no secondary hemorrhage, but thrombosis occurred.

In 1903 Exner experimented with the transplantation of blood vessels using the magnesium protheses of Payr. In six animals he transplanted portions of the external jugular vein into the carotid artery, but in all the cases thrombosis took place. In two dogs pieces of jugular vein, 4 cm. long, were transplanted into the opposite jugular vein, and in two other animals the same was done with the carotid arteries. In these cases also thrombosis was always present when the specimens were examined. Exner thought the failure of the latter experiments was due to the poor nourishment of the transplanted vessel, resulting from disturbance of the vasa vasorum.

In the same year Höpfner performed some experiments with the implantation and transplantation of vessels, and obtained more or less successful results. He likewise employed the magnesium protheses of Payr. Of two cases, in which sections of the carotid were removed and reimplanted, one was successful when examined four weeks after the operation. In one dog a section of the carotid 3 cm. long was transplanted into the femoral artery and a section of the femoral of the same length into the carotid; when examined eight weeks later there was no thrombosis, almost no constriction of the vessels, and their intima was smooth. In another experiment a portion of the carotid of one animal was transplanted into the femoral of another animal, and a portion of the femoral of the latter into the carotid of the former. The second experiment was successful, and the first was not, probably due to the fact that the wound in the neck healed per primam, whereas the wound in the groin healed by granulation. In 10 experiments, in which sections of veins were transplanted into arteries, although the technic was the same as in the other experiments and care was taken to have the valves of the veins point in the right direction, thrombosis always occurred. Höpfner concluded that such transplantations offer little prospect of being successful, for, when the current is turned on, there is a marked dilatation of the vein, and more or less stagnation of the blood, which leads to thrombus formation. In three experiments sections of vessels were transplanted from one animal species to another, but the result in all cases was negative.

Carrel and Guthrie, who, in this branch of vascular surgery also, have obtained the most remarkable results, speak of an autoplastic transplantation, when the section of vessel is taken from one vessel and transplanted into another vessel of the same animal, a homoplastic transplantation, when the section of vessel is taken from another animal of the same species, and a heteroplastic transplantation when it is taken from an animal of a different species. As a matter of fact, clinically it would be unnecessary to perform any but an autoplastic transplantation, for we can easily extirpate a short section of vein without interfering with the general circulation.

Transplantations may be (a) complete or (b) incomplete. In complete transplantations the segment of vessel is completely excised and then sutured between the cut ends of the other vessel. In incomplete transplantations the middle portion of the segment of vessel is allowed to remain attached to the surrounding tissues and to its branches; for example, a section of femoral vein can easily be isolated without disturbing its connection with the surrounding tissues and sutured between the cut ends of the accompanying femoral artery.

On removing the hæmostatic clamps, after transplanting a segment of vein into an artery, the segment of vein becomes distended with red blood until it is usually considerably larger than the artery, but, although they may be quite thin, its walls adequately support the arterial blood pressure. The pulsation in the vein is less marked than in the artery, for the vein is usually so distended that there is little excursion of the pulse wave. When the transplantation is incomplete and the segment of vein has branches, these branches do not immediately transmit arterial blood. At first they are filled with venous blood, which becomes displaced by the arterial blood as the valves are gradually forced. The branches then virtually become arteries.

Replantation and Transplantation of Organs and Limbs.

The replantation of an organ or limb consists in removing it, replacing it, and re-establishing its circulation by vascular anastomoses. The transplantation of an organ or limb consists in its removal and transplantation into another animal

or a different portion of the same animal, its circulation being re-established by vascular anastomoses.

In 1902 ULLMANN removed a dog's kidney and transplanted it into his neck, the renal artery being united to the carotid artery and the renal vein to the external jugular vein by means of Payr's protheses. The experiment was said to be successful, the kidney secreting normally after the operation. He does not state, however, how long this condition continued. Three months after this report, Ullmann reported having transplanted the kidney of one dog into another and the kidney of a dog into a goat. He exhibited the latter animal, and demonstrated the functionating kidney. When asked concerning the fate of the dog into whose neck the kidney had been transplanted, he did not say how long the animal had lived or how long the kidney had functioned. He said, however, that the kidney had been removed and on macroscopic examination several necrotic areas were seen; otherwise the kidney seemed normally nourished and had grown to the surrounding tissues.

In 1902 DECASTELLO also reported experiments with the transplantation of kidneys. He extirpated the kidney of a large dog and transplanted a kidney from another dog into its place uniting the vessels by means of protheses. The animal lived 40 hours during which time 1200 cc. of urine was secreted. Death was due to hæmorrhage resulting from separation of the venous anastomosis.

In 1905 FLORESCO reported certain experiments with the transplantation of kidneys. After several unsuccessful attempts he succeeded in extirpating the kidney of one dog and transplanting the kidney of another dog into its place the vessels being united by sutures. The end of the ureter was sutured into the skin incision. He does not give the ultimate results of the operation.

Since 1905 Carrel and Guthrie have made numerous experiments with the replantation and transplantation of organs and have obtained some very interesting results. One of their first experiments along these lines was the extirpation and replantation of the thyroid gland with reversal of its circulation. The right thyroid gland of a dog was dissected out and all its vessels ligated except the superior thyroid artery and vein. These vessels were divided, the gland removed and then replaced, the circulation being reversed by suturing the artery to vein and vein to artery. Eleven days after the operation the wound was opened and the gland found to be somewhat enlarged, but its hue and consistency were normal. Twenty-five days after operation the condition seemed practically the same. No histological examination was made, however. By reversing the circulation of goitres in dogs they claim to have produced a diminution in the size of the lobe operated upon and in one dog the goitre not only became smaller, but the general symptoms, referable to a hypothyroidism, largely disappeared. They think these phenomena were due to an augmentation of the circulation resulting from the reversal.

CARREL and GUTHRIE have used two methods of transplanting organs, *transplantation simple* and *transplantation en masse.*

The *transplantation simple* is the method which has been generally employed, but the objections to this method are that the nerves and their sympathetic ganglia are cut off from the organ and the veins are unduly exposed to injury, so that it is impossible to transplant such organs as the testicle and ovary by this method. To obviate these difficulties they developed the technic of *transplantation en masse,* which consists in extirpating the organ together with its surrounding connective tissues, its nerves and ganglia and its vessels with the corresponding segments of the large vessels from which they originate.

Making use of the simple method of transplantation Carrel and Guthrie have transplanted a heart, a loop of intestine, a kidney, and other organs into the neck. While the immediate result was, in most cases, satisfactory the ultimate result was usually disappointing. A kidney which was thus transplanted continued to function for some days.

The *transplantation en masse* has been used by Carrel and Guthrie in the transplantation of kidneys and ovaries. The technic of these operations is thus described by them.

Both kidneys and the upper portion of the ureters were removed from a small dog, along with their vessels, nerves, nervous ganglia, the surrounding connective tissue, the supra-renal glands the peritoneum, and the corresponding segments of the aorta and vena cava. The mass was placed in isotonic sodium chloride solution and later transplanted between the cut ends of the abdominal aorta and the inferior vena cava of a bitch. The circulation was re-established after having been interrupted one hour and a half. Clear urine flowed abundantly from the transplanted ureters which were anastomosed to the normal ones. Both normal kidneys were then removed. The dog recovered rapidly from the operation and remained in good health for eight days, during which time she secreted large quantities of clear urine, which contained no blood and was about normal in composition, the only abnormal constituent being a small amount of coagulable proteid. The dog died on the tenth day as a result of intestinal obstruction, due to a localized peritonitis on the right side of the abdomen. The circulation of both kidneys was perfect, but there was an enormous hydronephrosis on one side.

Ovaries were transplanted as follows: The specimen, consisting of ovary and a part of the Fallopian tube, united to the segments of the aorta and vena cava by a cellulo-peritoneal ribbon and the ovarian vessels, was taken from one cat and transplanted into another cat from which the corresponding tissues had been removed. The operation is said to have been successful.

Their experiments with *heteroplastic transplantations of organs* were unsuccessful, and they think that, on account of cytolysis, such transplantations are not likely to be successful.

The replantation of amputated limbs.—In 1903 HÖPFNER experimented with the amputation and replantation of the legs of dogs, uniting the femoral vessels in Scarpa's triangle by means of Payr's protheses. This was done in three animals. In the first case thrombosis occurred on the first day and gangrene followed; in the second case the circulation re-

mained intact 11 days, when death occurred under chloroform, while the dressings were being changed; in the third case thrombosis occurred on the sixth day and gangrene resulted.

CARREL and GUTHRIE have also made several experiments with the replantation of amputated legs of dogs, but none of these can be said to have been absolutely successful, for, although the circulation remained good for some days, obliteration of the vessels ultimately occurred.

AUTHOR'S EXPERIMENTS.

These experiments were begun with attempts to transplant the thyroid gland, making use of vascular anastomoses by Carrel's method. The attempts proved unsuccessful, so it was decided to apply this method to a series of arterial, venous, and arterio-venous sutures, with a view to determining in what percentage of cases we may expect a successful result.

The experiments were done on dogs of various sizes. When they could be obtained, large animals were used, but often it was necessary to make use of very small ones. The anæsthetic was ether, usually administered after a previous injection of one grain of morphine. The following technic was employed. After shaving a large area, the skin was cleaned with soap and water, permanganate of potash, oxalic acid and bichloride of mercury. The field of operation was then isolated with sterile towels and, after making the skin incision, sterile towels were clamped to the edges of the incision. The vessels were exposed, well freed and provisional hæmostasis produced by small spring clamps whose blades were armed with rubber. The vessels were then divided and prepared for suture by carefully removing the loose connective-tissue sheath about the ends of the vessel. This can be done very nicely by grasping the sheath with forceps, drawing it over the end of the vessel and clipping it off with scissors. The greatest care was exercised in handling the vessels, in order that they be injured as little as possible, and especial care was taken not to apply metallic forceps to the intima. Very fine (No. 16) straight needles and fine China bead silk were the suture materials employed, the thread being greased with or boiled in vaseline as suggested by Carrel. During the operation the

drying of the vessels was prevented by the application of normal salt solution or sterile vaseline.

The vessel sutures were done according to Carrel's method. The vessel ends were first united by three interrupted sutures equidistant from each other on the circumference of the vessel, the sutures penetrating all the coats of the vessel. By traction upon these sutures the edges of the vessels were nicely approximated and a continuous suture easily applied. It is convenient to leave the needles attached to the long ends of the primary sutures and to use these ends for the continuous suture. On turning on the current there was seldom any leakage, and when it did occur a slight compression usually caused it to cease in a few minutes. The tissues over the vessel were approximated with fine silk sutures and the skin wound was closed with a subcuticular suture of the same material. The wounds were dressed with silver foil and when the operation was on the neck a crinoline bandage was applied. When the wound was in the groin, it was usually dressed with collodion; sometimes a crinoline bandage was applied, which was usually torn off by the animal within 24 hours. Thanks are due Dr. R. R. Norris, of Washington, D. C., for assistance in many of these experiments.

Results.—The common carotid artery was sutured thirteen times. All of the sutures were perfectly successful and in no case was there the slightest evidence of thrombus formation. The femoral artery was sutured twice, thrombosis occurring both times as a result of wound infection. The external jugular vein was also sutured thirteen times, ten of the sutures being successful. (See figures appended.)

Microscopic examination of the arterial sutures at periods varying from twenty-eight to eighty-two days after the operation shows that there is a gradual restoration of the artery at the site of suture and that with the exception of the inner elastic membrane, all the elements of the vessel wall are probably regenerated. The sections of the thin-walled veins which were obtained were so distorted by the presence of the silk sutures that they were of little value for microscopic study.

The common carotid artery was sutured to the external jugular vein four times, all being successful. After the suture the veins became distended and pulsated vigorously; a marked thrill could be felt in the veins and a loud murmur heard over them. Examination of the veins one to three months after the operation showed a marked dilatation of these vessels, a thickening of their walls, and in some there were interesting placques in the intima, suggesting the changes seen in arterio-sclerosis. Microscopic examination of the walls of the veins revealed changes very analagous to those found in the walls of arterio-sclerotic arteries. In the vein of experiment 13 (see Fig. 12) the following condition was found: While all the coats of the vessel were greatly thickened, the thickening of the intima, especially in the regions corresponding to the white placques seen in the gross specimen, was very marked. The endothelial cells lining the intima were short and thick. The intimal thickening was composed of fibrous tissue fairly rich in cells. In certain places this tissue contained fewer nuclei and stained more poorly, but no atheroma was present. The thickening of the media was due to an increase in the interstitial connective tissue as well as to an increase in the size and number of its muscle cells. Where the intima was thicker the muscle cells seemed to be fewer and were separated by a considerable amount of connective tissue. The thickening of the adventitia was also well marked. There seemed to be a considerable increase in the elastic fibers of the intima, especially in the deeper portions near the inner elastic membrane, where a net-work of fine fibers was seen. In general, the elastic fibers seemed somewhat less abundant in the thicker placques, but at their edges and in their deeper layers numerous fine elastic fibers were seen, apparently invading them. The elastic fibers of the media and adventitia were diminished, but the diminution was more marked in the former.

The central end of the divided femoral artery was sutured to the distal end of the divided femoral vein four times. One case was successful; in the others thrombosis occurred. In the

successful case the leg became very much swollen after the operation and in two days was twice as large as the opposite one. The swelling gradually subsided but never entirely disappeared. The femoral vein became much dilated and marked pulsation could be felt in the saphenous vein near the foot. Examination three months after the operation showed a marked dilatation and thickening of the wall of the vein. The distal portion of the femoral artery was small, atrophic, and did not seem to be performing the functions of a vein.

In four animals a lateral anastomosis of the femoral artery and vein was made. In all the cases the immediate result was quite satisfactory; on turning on the blood stream there was no leakage, the vein became considerably distended, a thrill could be felt in it near the point of anastomosis and a humming-top murmur could be heard at some distance from the animal. The red arterial stream could be seen through the thin-walled vein, rushing into the vein and for the most part returning immediately to the heart. In only one of the animals, however, did the anastomosis remain patent, a marked thrill and loud murmur being present five weeks after the operation when the animal escaped from the paddock and was lost. In the second animal the murmur and thrill persisted for four weeks and then disappeared, examination a few weeks later showing that the anastomotic opening had healed, but that the vessels had remained patent. In the third animal, whose wound became infected, the thrill and murmur lasted only four days; examination two months later showed a thrombosis of the artery, the vein remaining unobstructed. In the fourth case the thrill and murmur persisted five or six days, death occurring on the eighth day after operation from secondary hæmorrhage.

Excision and replantation of a section of the femoral artery was done once, but thrombosis occurred. Transplantation of a section of vein into an artery was tried twice. In one instance a section of the external jugular vein was transplanted into the common carotid artery with perfect success. Examination of the specimen (see Fig. 15) twenty-six days after

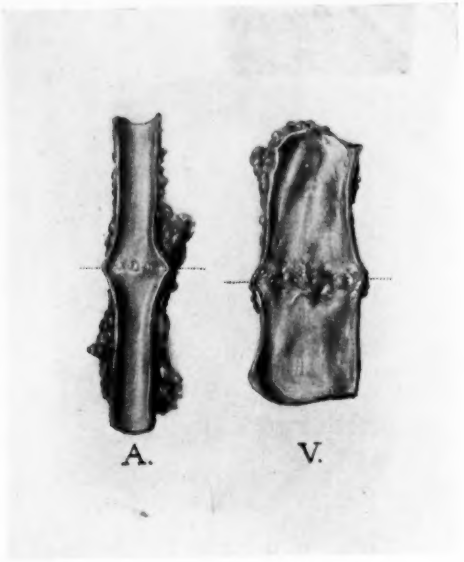
the operation showed considerable dilatation and thickening of the transplanted vein and the microscopic study of the vein revealed a condition very similar to that described above, resulting from the end to end anastomosis of the carotid artery and jugular vein. In the other case a section of the external jugular vein was transplanted into the femoral artery, but thrombosis resulted in a few days.

Transplantation of the thyroid gland was done six times, but none of these were sucessful. The failure of these experiments may be attributed to the small size of the inferior thyroid vein, whose diameter rarely exceeded two or three millimeters, and to the fact that the transplantations were undertaken before we had made any experiments with simple vascular sutures.

In reviewing our experiments we find that of thirty-one experiments upon the vessels of the neck twenty-eight were successful, whereas of twelve experiments upon the femoral vessels only two were entirely successful. This discrepancy is not difficult to explain. Wounds in the neck are inaccessible to the dog's teeth, and can be readily bandaged, the wounds being thus kept clean and dead space obliterated. In the groin, however, it is very difficult to apply a bandage which will remain in place, obliterating the large dead space which is so apt to be present and preventing movements of the leg which interfere materially with a successful vessel suture.

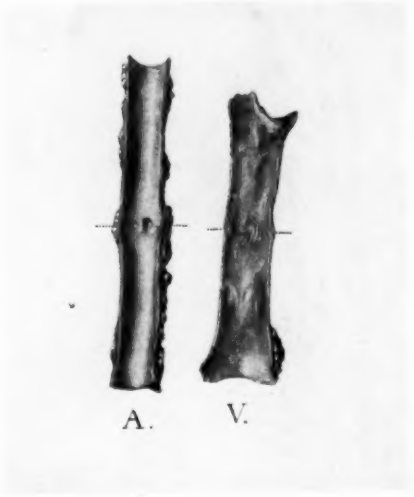
The results show conclusively that completely divided vessels can be sutured with almost uniform success, when the aseptic technic is good. The intima can be included in the suture with impunity, the application of the suture being thus greatly facilitated. Nearly all experimenters with the suture of blood-vessels have called attention to the need of a very perfect technic. I wish also to emphasize this point, for I consider infection by far the most important factor in producing thrombosis after vascular sutures. I think, as Carrel does, that there may be minor grades of infection, which, although allowing per primam healing of the wound, may be sufficient to produce thrombosis of the sutured vessels.

FIG. 1.



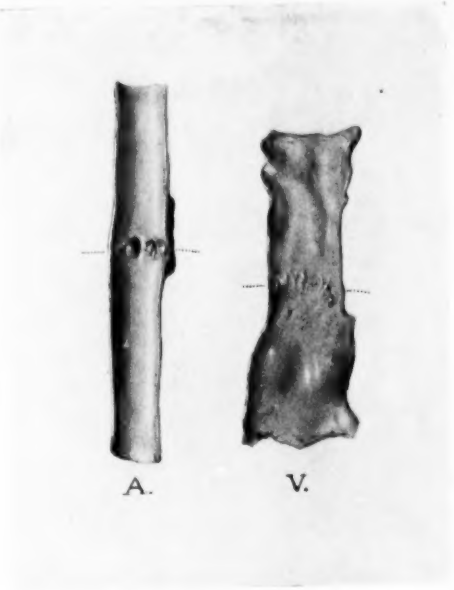
Circular suture of carotid artery and jugular vein, 28 days after operation.

FIG. 2.



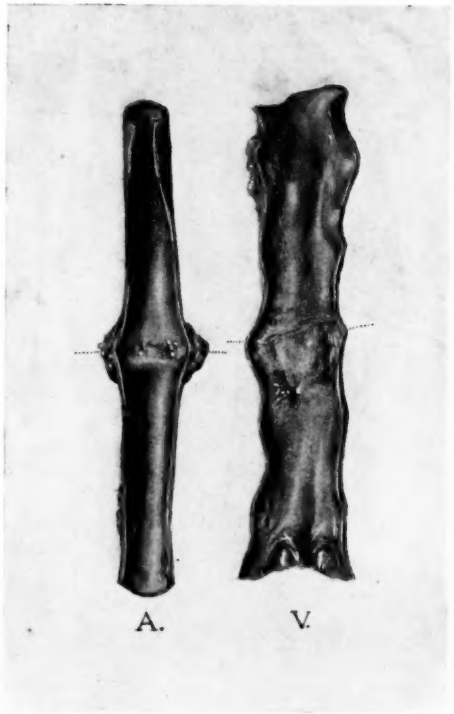
Circular suture of carotid artery and jugular vein, 42 days after operation.

FIG. 3.



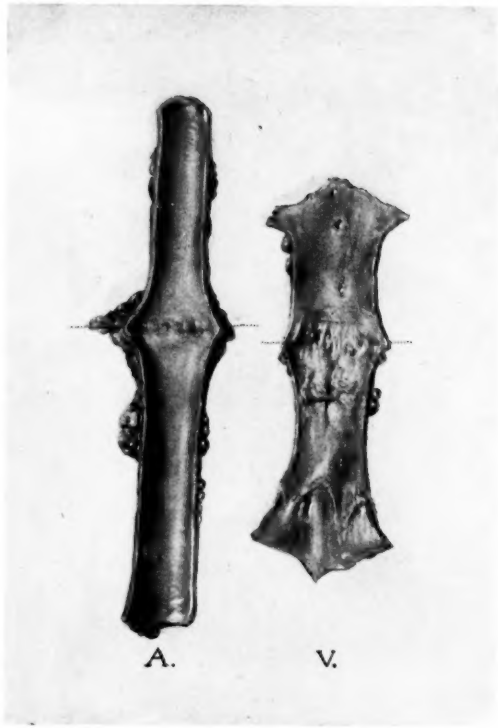
Circular suture of carotid artery and jugular vein, 35 days after operation.

FIG. 4.



Circular suture of carotid artery and jugular vein, 82 days after operation.

FIG. 5.

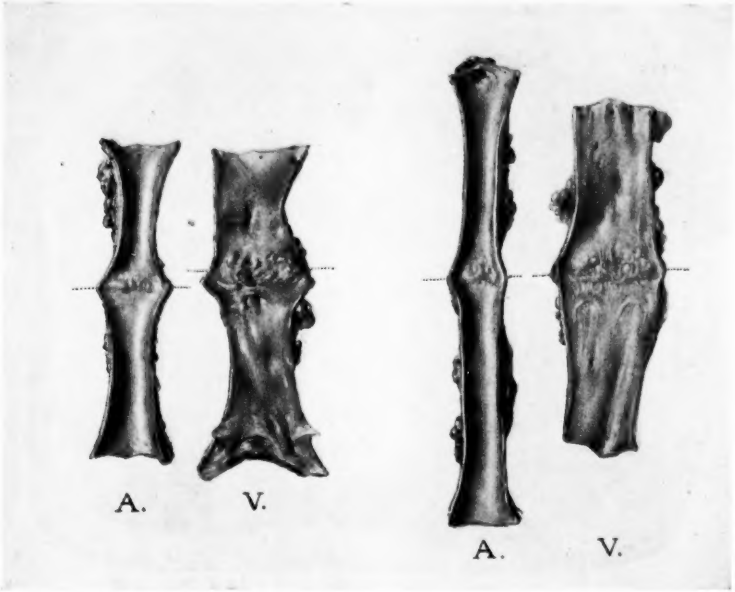


Circular suture of carotid artery and jugular vein, 48 days after operation.

FIG. 7.

Circular suture of carotid artery and jugular vein, 32 days after operation.

FIG. 6.

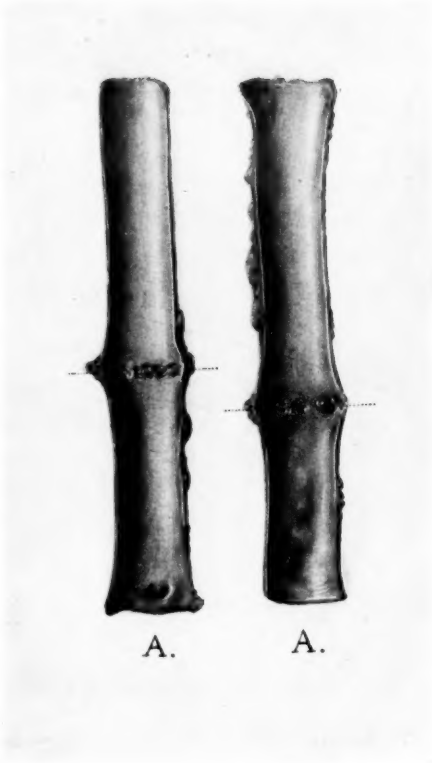


Circular suture of both carotid arteries and both jugular veins, 41 days after operation.

FIG. 8.

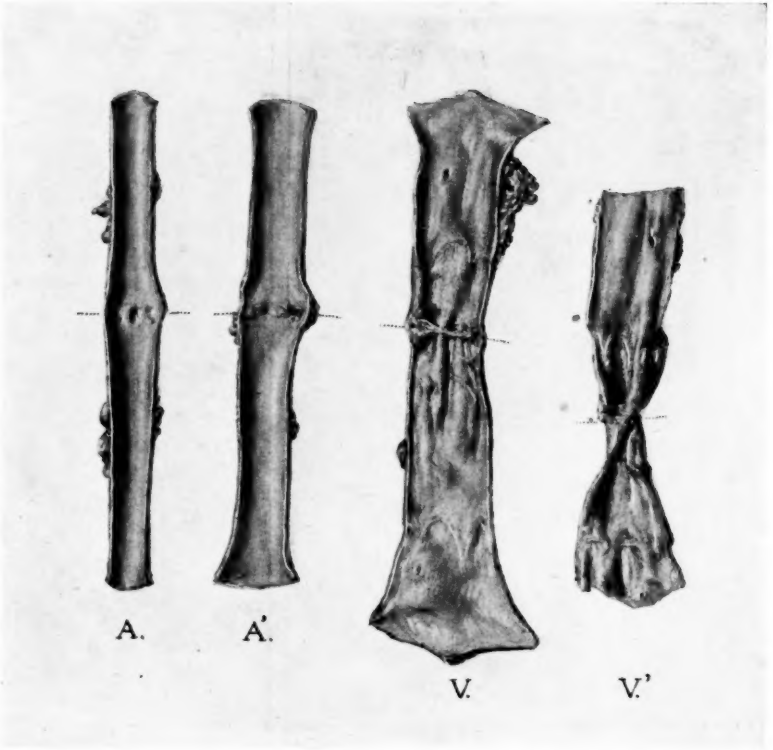
Circular suture of carotid artery and jugular vein, 26 days after operation.

FIG. 9.



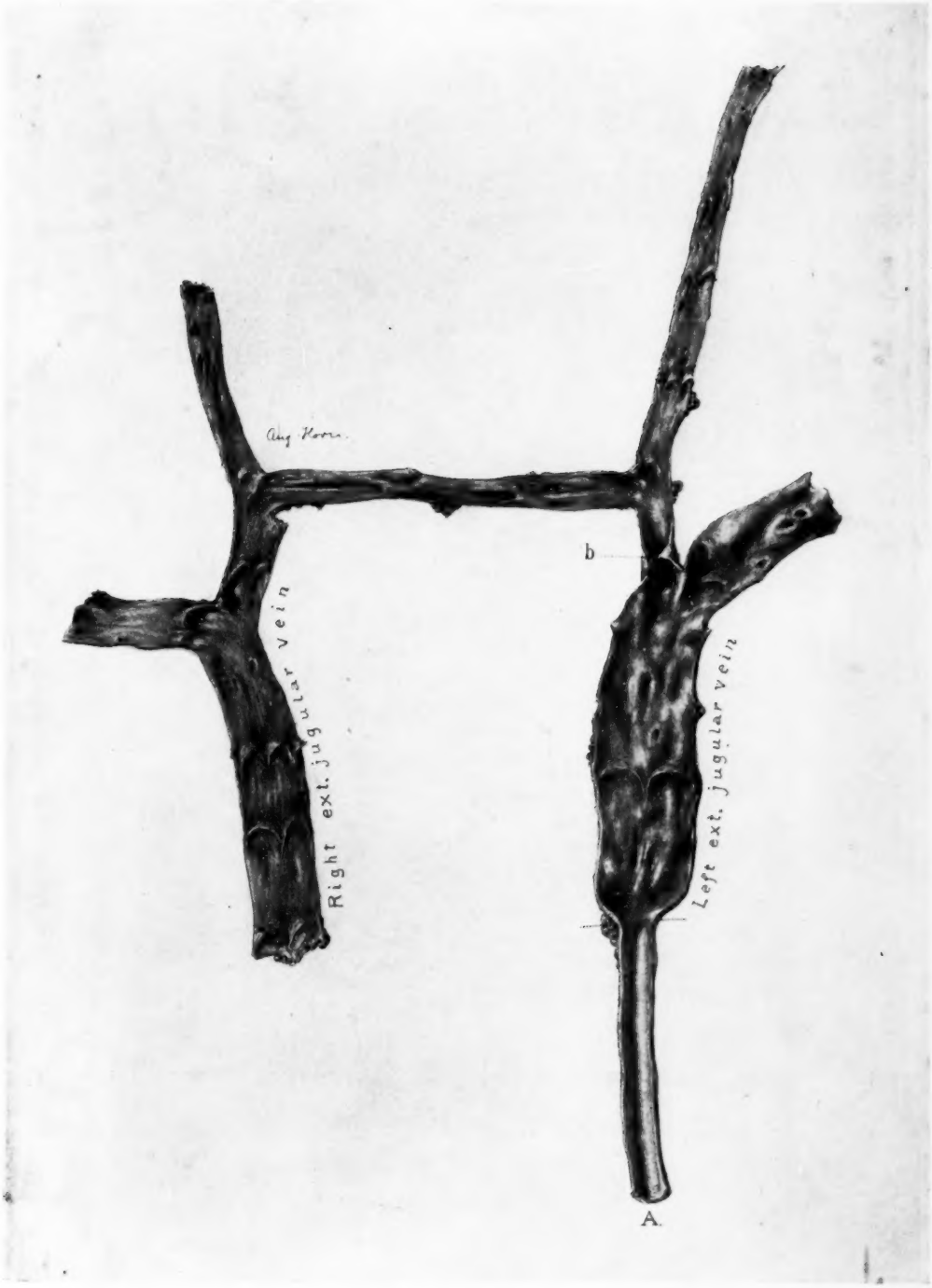
Circular suture of both carotid arteries, 18 days after operation.

FIG. 10



Circular suture of both carotid arteries and both jugular veins, 17 days after operation.

FIG. 11.

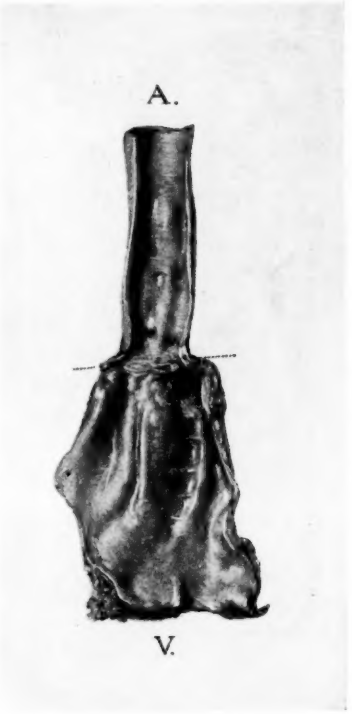


Circular anastomosis of the left common carotid artery and left external jugular vein, 4 months after operation. As a result of arterial pressure this vein is much thickened and dilated. Small branch of vein occluded (b), probably due to valves being forced together and becoming adherent

FIG. 12.

Circular anastomosis of carotid artery and jugular vein 3 months after operation. Marked sclerosis of vein.

FIG. 13.

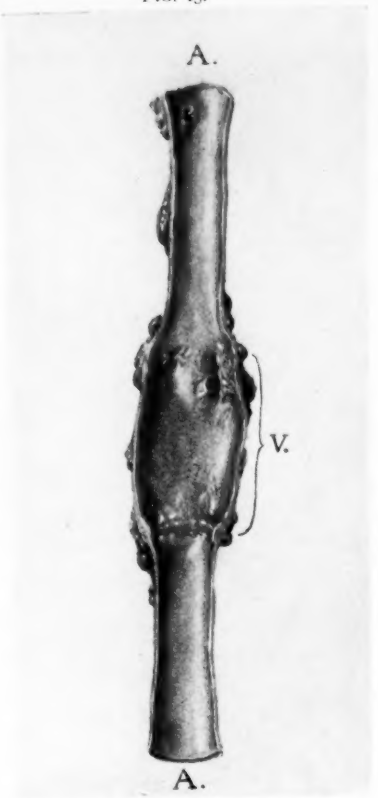


Circular anastomosis of femoral artery and vein, 3 months after operation. Marked thickening and dilatation of vein.

FIG. 14.

Circular anastomosis of carotid artery and jugular vein, 40 days after operation. Note thickening and dilatation of vein.

FIG. 15.



Transplantation of section of jugular vein into the carotid artery, 26 days after operation.

THE OPERATIVE TREATMENT OF ACUTE ABSCESS OF THE LUNG.*

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OF NEW YORK,

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THE operative treatment of abscess of the lung, while it goes back to Hippocrates, was not put upon a sound basis until the latter part of the last century. Hippocrates recognized that abscesses of the lung not unfrequently ruptured into a bronchus and could thus be healed spontaneously, and in other cases broke into the pleura and then justified incision or opening with a cautery. In the eighteenth century De Barry and, later, Sharpe recommended operative procedures for abscess and other cavities. In 1845 Stokes attempted the opening of pulmonic cavities with the trocar. In 1873 Mosler, an internist, inaugurated the present period of lung surgery. Since then Quincke, Tuffier, Gluck, Karewski, and Garré have been important contributors to this branch of surgery. Progress became more rapid after it had been learned that the dangers of pneumothorax could be avoided, that the lung tissue stood well the invasion of the knife and cautery, and that hemorrhage need not be dreaded.

It is only of late years that an accurate differentiation of the suppurative lesions suitable to surgical treatment has been made, and definite indications and limitations have been laid down for the guidance of those contemplating operative interference. It is still true that lung abscess may present great difficulties of diagnosis, and this is likely to be the case at a stage of the disease when the prospect for a cure by operation is the most hopeful, *i.e.*, in fresh cases with the patient in a good general condition, slight extent of the suppurative process and no complications. In spite of greater accuracy in physical

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signs, and sputum examinations, and the added information from radiography, the diagnosis of suppurative lesions within the lung is still far from satisfactory. Discrepancies between the findings of the medical men and the revelations of the surgeon and pathologist are still of common occurrence.

Not only are the various acute and chronic suppurative lesions within the lung itself frequently mistaken for each other, but various conditions outside the lung are often wrongly claimed as intrapulmonic in origin. One has only to read carefully the histories of reported cases of abscess of the lung to find among them many of probable interlobar empyema or an empyema sacculated or general that has broken secondarily into the lung and bronchus. The best observers have been at times unable to distinguish correctly between an encapsulated intraparenchymatous and encapsulated pleuritic collection. It is equally true that many cases of abscess of the lung break into the pleural cavity, causing an empyema, which is drained and the existence of a primary lung abscess never suspected. Many of the instances of the slowly healing empyemas can doubtless be explained on the ground of persistence of a suppurating focus within the lung, which continues to discharge into the pleural cavity. For these reasons the frequency of acute abscess of the lung is stated very differently by different observers. Some of our medical confrères claim that it is a comparatively frequent condition following pneumonia, and point to numerous cases of spontaneous cure from evacuation into a bronchus. It should be borne in mind that a localized empyema may easily give the same physical signs as abscess of the lung, and very commonly perforates like an abscess into the bronchus. Other medical men recognize the infrequency of lung abscess following pneumonia, which is its most common antecedent, and place it among the rarest complications of that disease. Fraenkel, for example, found that in 860 cases of pneumonia under his observation, abscess of the lung occurred only in 1.5 per cent. of the cases.

Within the lung itself the various forms of suppuration are often not differentiated in the lists of reported cases, and

are classified together in symptomatology, prognosis, and treatment. While it is true that these different forms may have a resemblance to each other as regards symptoms, they should be strictly differentiated as regards indications *for* and results that may be expected *from* operative treatment. I think from a surgical standpoint we should carefully distinguish: First, acute abscess, simple and gangrenous; second, chronic abscess; third, bronchiectasis. Tuberculosis and actinomycosis belong in a still different category.

Acute abscess has been shown to follow most frequently lobar pneumonia. Tuffier found this to be the case in 23 out of 49 cases. Other causes are septic embolism and extension of suppuration from adjacent parts. The aspiration of foreign bodies usually results in an abscess of the chronic type that may eventually go on to bronchiectasis. The prognosis from the operative treatment of the chronic suppuration is so distinctly in another class from that of the acute that I have preferred to limit myself in this paper to the treatment of the acute. It is by directing our attention to the acute form of suppuration that we shall be able to prevent a certain percentage of the chronic cases which offer such a poor outlook for surgical interference. We cannot trust to Nature for a spontaneous cure by evacuation of the pus through a bronchus. If we could, there would be fewer cases of the chronic form come to our attention. We should interfere at an early stage before the abscess walls and surrounding tissue become hard and indurated, and the adjoining pleura thickened and unyielding, favoring a continuation of the suppuration and preventing a collapse of the abscess walls. The operative treatment of chronic abscess includes so much more than is necessary in acute abscess, and the conditions for healing are so unfavorable, that the two forms of abscess have little in common. To bring a chronic abscess to healing implies usually an extensive resection of ribs, removal, perhaps, of thickened pleura, and even then a sinus is likely to persist. On the other hand, the operative treatment of acute non-gangrenous abscess is in itself simple, and recovery should be the rule. The great difficulty

lies in an early recognition of the disease and in an accurate localization of the focus.

As regards the justification for operative interference in abscess of the lung, we must recognize the fact that spontaneous recovery is possible. Many abscesses of pneumococcus origin have undoubtedly healed after evacuation of the pus into a bronchus. In the absence of a gangrenous element, the abscess may not enlarge rapidly nor cause marked septic symptoms. Its walls not having become indurated coalesce after discharge of the pus, and cicatrization may be prompt and complete. On the other hand, we cannot be at all sure that this favorable result will follow. As these abscesses are often near the pleural surface they can easily give rise to empyema, which in such cases runs a severe and protracted course. Furthermore, if they persist as such their walls become thickened and unyielding, and later resist even extensive operative procedures. Spontaneous cures should be looked upon as a fortunate accident, and not waited for to the risk of the patient's life or future condition of health. The continued presence of an abscess within the lung should be regarded as a serious condition. Instead of rupturing into a bronchus it may at any moment break into the pleural cavity, give rise to multiple abscesses in the lung, or cause dangerous septic manifestations. When, however, the abscess has already broken into a bronchus and is discharging freely, it would seem proper to wait a time for nature to finish her cure. Should the discharge of pus per mouth not diminish rapidly, and the septic symptoms continue, we should not delay long. Evidences, however, of a gangrenous nature on the part of the abscess indicate very strongly early operation. The danger here is greater of infecting other parts of the lung and causing general sepsis.

Other reasons justifying some delay in operating are the persistence of the acute pneumonic process and the desirability of having firm adhesions of the two pleural surfaces. These should not, however, be allowed to weigh against early evacuation of the pus when there are well-marked indications for the same. Quincke claims that the duration of the disease has no

influence upon the presence of adhesions. Their existence is probable if there is a previous history of sharp pain on that side and other evidences of inflammation of the pleura.

In spite of the fact that the operative technique of pneumotomy is comparatively simple, this operation is often unsatisfactory and disappointments are not uncommon. In the first place the abscess, though present, may not be found. This may be due to the fact that its location has not been accurately made out beforehand. It is one thing to diagnose the existence of an abscess and quite another to locate it exactly. Mistakes can be made as to its height and depth. The experience of the past will help us here. The great majority of abscesses following pneumonia occur in the lower lobe and near the pleural surface. Furthermore, the location of the adhesions between the pleural surfaces is usually an important guide to the situation of the pus cavity. After the exposure of the adherent pleura the aspiration syringe should ordinarily locate the pus if introduced a number of times in different directions and to various depths. If there are no adhesions found at the point where the pleura has been exposed, the proper procedure, it seems to me, is to make a small opening in the parietal pleura large enough to admit a finger, and in this way a search can be made for adhesions. This " exploratory pleurotomy " done in this way, as first recommended by Bazy, may give valuable information, not only as to the location of adhesions, but the focus itself may be made out by feeling a firmer consistency of the lung at one point, a bulging of the surface, or a thickened pleura. The danger of making such a small opening in the pleura which is at once filled with the finger is very slight. The resulting pneumothorax is only partial, particularly if adhesions are present at one or more points, and even without adhesions the collapse of the lung is not complete, and the patient suffers no alarming symptoms. Bazy found in this way a gangrenous focus in the upper lobe of the right lung in a young man of twenty, in spite of the fact that the physical signs pointed to a localization of the cavity in the lower lobe. After resection of the eighth and ninth ribs the pleura was found to be healthy.

Upon inserting the finger he felt higher up an induration of the lung and adhesions. Thereupon he resected the fourth rib and opened an abscess cavity in the subjacent portion of the lung. Such a favorable result cannot, of course, be expected in every case that this method is used, but it seems advisable in cases where no adhesions are found at the point of resection of ribs. By uniting the non-adherent pleural surfaces without this exploration, we lose a valuable diagnostic method. The absence of adhesions carries with it considerable doubt as to whether the abscess will be found directly beneath the exposed pleural surface inasmuch as adhesions are the rule.

The more extensive exploratory operations in which the pleural cavity is opened widely and the lung palpated over its entire surface has no place in suppurative lesions in the lung. The same is true of the extrapleural method of Tuffier, in which the parietal pleura is dissected up for some distance from the subjacent fascia, thus making it possible to palpate the lung without opening the pleural cavity. The first operation is very dangerous on account of the complete pneumothorax and the probable infection of the pleural cavity, provided the abscess is found and opened in the same sitting.

The second operation is very difficult, prolonged and in the end unsatisfactory. Should, in spite of the Bazy procedure, no adhesions at all be found, and the existence of an abscess still be thought probable, the formation of adhesions by means of suture should be the next step before the introduction of an aspirating needle. In this way alone can we be sure that the needle when withdrawn after finding pus does not infect the healthy pleural surfaces. In case a pus focus is not discovered by means of a needle plunged in different directions through adherent pleura into the lung tissue, we should not hesitate to go further in case other signs point to the existence of an abscess. An incision can without danger be made into the lung tissue with the knife or thermocautery, or the finger or blunt instrument can be bored in until a cavity is reached or the hæmorrhage has become too free. By inserting gauze into a canal thus made the breaking through of pus is favored, and

eventually the abscess may be evacuated. A number of cases have been recorded in which this favorable result has occurred. The danger of serious hemorrhage is not great in the superficial portion of the lung, and it is not until the larger vessels of the deeper parts are reached that the bleeding becomes profuse. Had this direct exploration of the lung been more often practised, fewer cases would be on record where the abscess cavity had been left unopened and discovered only at autopsy. Besides, in not finding the abscess the operation may result in a fatal pneumothorax or infection of the healthy pleura. Should a complete pneumothorax and resulting collapse symptoms occur in spite of the precautionary measures already spoken of, the patient may be saved by prompt measures. The lung may be seized with tenaculum forceps and drawn forcibly against the wound in the pleura and retained there by sutures. Furthermore, the lung may be expanded by means of the O'Dwyer intubation tube or some similar apparatus. Should the pus be opened into the healthy pleura there is very great danger of a fatal empyema, especially in a person already septic and weakened. An attempt should be made, however, to provide for proper drainage at the most dependent part of the thoracic cavity. For this purpose resection of a portion of the ninth rib should be done.

Most of the other bad results from operation for acute meta-pneumonic abscess of the lung may be put down to non-recognition of the abscess and consequent delay in operating until the patient's condition has become too poor from sepsis to expect anything but a fatal outcome, or to the existence of multiple abscesses secondary to the original one or to some other complicating process. These bad results seem, therefore, nearly all avoidable, provided that the case comes under the physician's observation from the beginning. Better results from operation will follow from more prompt recognition on the part of the internist of the existence of an abscess, a more accurate diagnosis of the location of the same, and from earlier operative intervention. The mortality at the present time is far higher than it should be, and in reality should approach

that of empyema. The mortality as given in statistics, such as Tuffier (23.8 per cent.), which are computed from published cases, seems lower than it really is, as shown in unpublished records taken from one or more hospitals. Here will be found the successful and unsuccessful cases recorded together. I have made such a compilation of hospital cases which have been operated on during the last ten years. This shows a mortality of 50 per cent.

As regards operative technique, certain points seem of special importance. In the first place, the incision is preferably curved with convexity downward, and should correspond to the lower level of the abscess. This will insure the best drainage, and will permit of added resections of ribs at a higher level. One or preferably two ribs are resected for a sufficient distance and, later, if necessary, further resections may be added. The parietal pleura should be then carefully inspected to detect any thickening, adhesions, or other abnormality. The existence of adhesions is of great practical importance, as we have already seen, and fortunately are the rule in abscess cases. Tuffier found that they were present in 87 per cent. of the cases. In some instances there is a localized exudate, seropurulent in character, between the two pleural surfaces. The method used for the production of adhesions has changed considerably in the evolution of lung surgery. Quincke, an acknowledged authority on abscess of the lung, still uses his cauterization method. Applications of chlorid of zinc paste are made repeatedly for several days, and at the end of two weeks adhesions are usually present. Other observers claim that they have had no results from this method. It is certainly unsurgical, and does not appeal to the aseptic operator. Suture of the two surfaces seems to be the method of choice. Inclusion of lung tissue by the stitches has the advantage of greater security of the line of suture. The additional use of gauze packing is highly recommended by some and certainly helps in the production of broad adhesions. It is desirable to form a sufficiently large area of adhesions, as the movements of the lung find in this way greater resistance, and the sutures are less

likely to tear out. Furthermore, a larger area of the lung lies attached in the wound, and any slight error in the diagnosis of the location of the abscess will be of less consequence. Round needles are preferable, and Garré recommends inserting them during expiration and covering the pleura with the finger during inspiration.

If the suturing has been done satisfactorily, the incision of the pleura can be done at once without putting it off to a second sitting. If, however, the patient's condition is good the delay of a couple of days will doubtless ensure stronger adhesions without lessening the patient's chances.

If the strength of existing adhesions is in doubt, sutures should be used for reinforcement, so that the introduction of the scalpel or trocar will not cause the adhesions to give away, followed by pneumothorax and separation of the lung from the field of operation. This experience happened to me in operating upon an abscess of embolic origin. The pus had been located by means of the aspirating needle passed through an adherent portion of the pleura. Upon inserting a sharp-pointed knife along the needle, the weak adhesion gave away, air entered, and the lung receded out of reach. A strip of gauze was hastily packed into the pleural cavity so as to come in contact with the area of the lung that had been adherent. The patient suffered no ill effects from the pneumothorax and a few days later the abscess perforated into the gauze packing. Within a short time the pus ceased to discharge, the fistula closed, and the patient made a perfect recovery.

As regards the method of dividing the lung tissue before reaching the abscess, surgeons hold various opinions. The general rule seems to be that the thermocautery (at a red heat) is preferable when the lung tissue is soft and vascular, as the oozing is undoubtedly checked and infection is less likely to penetrate the line of incision. The knife, however, is more suited to indurated tissues and does not obscure the tissues as does the cautery. The tip of the forefinger is an effective instrument in boring into lung tissue, and has been recommended by many operators expert in this branch of surgery.

The cavity having been opened, the treatment is similar to that of most abscess cavities, with the exception that irrigation should not, as a rule, be employed. The danger of spreading the infection into the adjacent tissues and, particularly when there is a communication with a bronchus, into other parts of the lung, is a real one, and fatal results have undoubtedly been caused in this way. In exceptional cases of gangrenous abscesses, with very foul contents and no communication with a bronchus, it may be desirable to run some risk on account of the detriment of the patient from the continued absorption from the septic contents. In one extensive abscess, with a large amount of secretion, I obtained the best drainage by means of a long tube connected with a bottle at the side of the bed. The dressings remained comparatively dry and thus their frequent change, which would have been necessary in case a short tube had been used, was done away with, which is no small consideration in the cases of these weakened individuals. Tube drainage seems to me preferable to any other in large abscesses. The danger of erosion of vessels from pressure is not present here as in chronic abscesses and bronchiectases, and hence the precaution of covering the tube with gauze is not essential. I have tried in all cases to keep these patients out of doors as much as possible on the roof or fire-escape. Their general condition is immensely improved thereby; they sleep better, their appetite improves and recovery seems hastened. The average time for healing seems about eight to ten weeks. This depends a good deal upon the length of time that the abscess has existed before operation. In the long standing cases the fistula may remain open for many months. Subsequent examination of the lung fails to show anything abnormal left behind by the abscess, and it is only very exceptionally that an inflammatory process is started up afresh.

If we turn to abscesses of origin other than lobar pneumonia we find the results from operative treatment are, generally speaking, far less favorable.

Embolic abscesses are frequently multiple, and in that case are not adapted to surgical treatment. Furthermore, the

cases in which the abscess in the lung is single, are frequently associated with purulent foci elsewhere in the body, and thus offer a poor outlook for recovery, even though the pulmonary focus is found and drained. Operation, however, should be attempted in suitable cases and the abscess opened and drained, just as in the meta-pneumonic abscess. Williams reported an abscess of the lower lobe following septic miscarriage in which adhesions were present, and the recovery followed incision and drainage. I had recently a successful case of embolic abscess in which there were three other pus foci in the body. The small single abscess in the lung was successfully opened and drained.

Abscesses following influenza-pneumonia are frequently multiple on account of the breaking down of disseminated areas of consolidation. They do not usually communicate with a bronchus, and run a more chronic course. The prognosis is hence distinctly worse than in the single abscesses of lobar pneumonia. Should the purulent foci be close to each other it may be possible to drain them by opening up one abscess and breaking down the intervening tissue. In general, however, operative treatment should not be extended to this multiple form of suppuration. Abscesses due to the aspiration of foreign bodies also show an unfavorable prognosis. These abscesses usually belong to the chronic type, often become multiple and develop into bronchiestasis. It is seldom possible to find the foreign body after opening the abscess, and unless the body is coughed up or removed by means of a bronchoscope, the abscess does not heal. Out of 14 cases the foreign body could be found and removed through the wound in only two instances. Such patients usually succumb to prolonged suppuration or to pyæmia.

The following statistics based on 20 cases of acute abscess have been taken chiefly from the records of several of the large hospitals in this city. They are all cases that have been operated upon within the last ten years. All cases in which an abscess was not actually found within the substance of the lung at the operation or subsequent autopsy have been excluded

from the list. Many cases were found tabulated in the records as " Abscesses of the lung," which seemed from careful perusal to be cases of sacculated empyema or empyema that had ruptured into the lung and bronchus. These were naturally excluded as well as all cases in which there were insufficient data as to the duration, nature of the abscess, etc. I have selected the acute cases of abscess for the reasons given at the outset of this paper. I have been impressed with the rarity of the condition, as shown by the surgical records. As regards the sex, the relative frequency in males is rather striking—17 males and 3 females. Etiology shows a decided preponderance of pneumonia as the underlying—15 cases.

The duration of pulmonary symptoms and the nature of the abscess have seemed of special importance as bearing upon the results of operative treatment. Abscesses of long duration and those with gangrenous contents show a bad prognosis. The two cases of multiple abscess died. With one exception all the cases of simple abscess of less than eight weeks' history and with non-gangrenous contents recovered. This case might, it seems to me, have recovered had not irrigation been used. All the gangrenous abscesses died; in one of them, however, the abscess was not found at the operation, but the autopsy showed that it was only an inch from the surface.

The operative result in the 20 cases shows a mortality of 50 per cent. This seems high, but when we consider that cases are here included of four and five months' duration before operation, and those of a gangrenous character, we realize that we are dealing with severe lesions. Without operation all such cases must necessarily be fatal. Our hope of good results seems to lie in the simple abscesses which are discovered early, before they have become extensive, multiple, or complicated by empyema, and before the patient has grown septic. Cases of lobar pneumonia which run an irregular course suggesting secondary empyema and in which pus is not obtained by trial puncture of the pleural cavity, should be regarded with suspicion. They should not be permitted to drag along in the medical wards until the favorable time for operating has

passed. It is far safer to explore such cases by resection of one or more ribs, palpation and inspection of the pleura, search for an adherent area, and trial punctures of the lung through the adherent portion. If pus is present within the lung it should be found in this way at the time, or may be evacuated later spontaneously through the wound. If pus is not present, no harm has been done by the simple operative procedure at a time when the patient's general condition is good.

SYNOPSIS OF TWENTY CASES OF ABSCESS OF LUNG.

Case No.	Sex.	Age.	Etiology.	Duration of Pulmonary Symptoms.	Condition of Pleura.	Nature of Abscess.	Result.	Remarks.
1	M.	26	Secondary to abscess of liver.	3 months.	Adherent.	Simple.	Death.	
2	M.	50	Pneumonia.	3 weeks.	Adherent.	Gangrenous	Death.	
3	M.	42	Pneumonia.	8 weeks.	Adherent.	Simple.	Recovery.	Abscess cavity not found but ruptured subsequently into wound
4	M.	23	Embolic.	5 weeks.	Slightly adherent.	Simple.	Recovery.	Secondary abscesses in joints.
5	M.	43	Pneumonia.	4 weeks.	Adherent.	Multiple.	Death.	
6	M.	5	Pneumonia.	3½ wks.	Adherent.	Simple.	Recovery.	
7	M.	11	Metastatic (appendic.)	5 weeks.	Adherent.	Multiple.	Death.	
8	F.	23	Pneumonia.	4 weeks.	Adherent.	Gangrenous	Death.	Autopsy. Abscess not located at operation.
9	M.	25	Pneumonia.	3 weeks.	Adherent.	Gangrenous	Death.	Lived 6 weeks.
10	M.	40	Pneumonia.	4 weeks.	Adherent.	Simple.	Death.	Irrigation.
11	F.	22	Pneumonia.	5 months.	Associated empyema.	Simple.	Death.	Lived 3 months.
12	M.	21	Pneumonia.	4 months.	Adherent.	Simple.	Recovery.	
13	M.	53	Pneumonia.	4 weeks.	Adherent.	Simple.	Recovery.	
14	M.	38	Pneumonia.	3 weeks.	Adherent.	Simple.	Recovery.	
15	M.	28	Pneumonia.	4 months.	Sero-purulent exudation.	Gangrenous	Death.	Lived 5 weeks. Whole lower lobe involved.
16	M.	10	Pneumonia.	2 months.	Adherent.	Simple.	Recovery.	Previously broke into bronchus.
17	M.	40	Pneumonia.	4 weeks.	Adherent.	Simple.	Recovery.	
18	M.	25	Embolic.	3 weeks.	Adherent.	Simple.	Recovery.	
19	F.	55	Pneumonia.	3 weeks.	Adherent.	Simple.	Recovery.	
20	M.	17	Influenza.	4 weeks.	Adherent.	Gangrenous	Death.	

CONCERNING A DISTINCT TYPE OF HYPERNEPHROMA OF THE KIDNEY, WHICH SIMULATES VARIOUS CYSTIC CONDITIONS OF THAT ORGAN.

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THE pathological diagnosis of tumors of the kidney has made notable and permanent advances within recent years. In addition to the old and well recognized types of sarcoma and carcinoma among the malignant neoplasms which affect that organ, the so-called teratomata, which often assume many of the clinical characters of malignancy, have come to be definitely established. Of these, at least three types are known —the embryomata, or "Wilms' tumors," containing glandular tissue, striated muscle, and occasionally other elements; the adeno-sarcomata of Birch-Hirschfeld, grouped by many authors as tumors of the Wolffian duct, [2, 5] by others as a species of the Wilms' tumors; [1 2] and the Grawitz tumors, or hypernephromata. These various types of new growths possess certain characteristics of their own, both in their clinical course and in their prognosis, which renders their recognition an extremely important object in diagnosis; and yet it cannot be gainsaid that this recognition still remains in very many of the cases little less than a diagnostic impossibility. The cause of this difficulty is not very far to seek, for, as pointed out by Thorndike, in almost all the recent publications which deal with these growths, their histological features have been made the subject of elaborate study and description, almost to the complete exclusion of their clinical characteristics. It would seem, however, that the time had arrived when a more careful study and definition of the latter aspect of the problem might be fruitful in practical results. It is quite evident that tumors

which differ so markedly in their course, their prognosis and, under certain conditions, in the indications for treatment cannot be profitably thrown together in the nondescript category of malignant neoplasms of the kidney.

In the following paper, an attempt has been made to define a certain group of hypernephromata, which offer many difficulties in the way of diagnosis, and yet which seem, upon closer analysis, to present certain peculiar characteristics, which are sufficiently individual to render their recognition possible.

An example of this group is offered by a very typical case which was recently observed in the German Hospital in New York City. The patient, E. W., a man 56 years of age, was admitted to the hospital in June, 1904. For the following details I am largely indebted to Dr. Kammerer, in whose ward he lay, and also to Dr. H. Klein,[6] who had previously presented him at a meeting of the German Medical Society for diagnosis. His family history is irrelevant. His personal history up to the age of 16 makes mention only of the diseases of childhood. At the age of 16 or 17, he had an attack of hæmaturia, which lasted for almost two weeks. At this time he had no pain, and no other evidences of disease. From that time until 1899, a period of thirty-five years, the patient remained in every respect perfectly healthy, so far as he knew. In November, 1899, he again observed the presence of blood in the urine, which persisted for several weeks, and led him to seek the German Hospital in December. His only complaint at that time was weakness and occasional vertigo, due probably to the loss of blood. He had no pain either during or after urination. His urine at that time contained red cells, epithelia, leucocytes, and a few hyaline casts, and measured 1300–1500 cc. per day. He remained in the hospital for about five weeks, during which time the urine gradually cleared up, and in January, 1900, he left, apparently cured. He had presented no œdema and no uræmic symptoms of any kind. No clinical diagnosis was noted. About a year later he had an exactly similar attack, which lasted four to six weeks, and since then three more attacks, at intervals of several months. In general, these attacks were all of similar nature, and each one left him weaker and more anemic than before, so that for a year

previous to his admission to the hospital he had been unable to follow any occupation. In March, 1903, he first noticed an increase in the size of his abdomen, which steadily progressed. This went hand in hand with a sense of fulness and of oppression in the epigastrium after eating, and with a gradual diminution of appetite. During this period the patient thinks that he lost about ten pounds in weight. He has suffered from constantly increasing weakness, vertigo, and other anemic symptoms, which have always been aggravated just prior to the onset of his hematurias. He has never passed a stone or gravel, and has never had any form of colic.

Physical examination.—Man of medium height, with poor skeletal and muscular development. Considerable emaciation. Pallor of skin and visible mucous membranes marked. No œdema over malleoli or sacrum. Examination of the thorax reveals nothing of note, except slight upward displacement of the apex beat, and a few rales at the bases, especially marked on the left side. The abdomen is markedly distended, especially on the left side, and there are large and torturous veins in the skin of that side of the abdomen. By palpation, a tumor mass is found to occupy practically the entire left side of the abdomen, extending well beyond the middle line, including the entire umbilical and upper part of the pubic regions, and left lateral portions of the abdomen. In the midsternal line, it can be felt as high as three fingers' breadth below the ensiform, and as low as four fingers' breadth below the umbilicus. It appears to be smooth, rounded, tense, but slightly fluctuating, and exhibits no respiratory mobility. It is not tender. The liver and spleen are not palpable. The percussion note over the mass is uniformly flat, except for a tympanitic band, presumably ascending colon, towards the left flank. It is separated by a narrow tympanitic zone from the area of liver flatness. No evidence of free fluid in the abdomen. The urine is dark red, opaque, and contains coagula; albumen is present in varying amounts. Microscopically, numerous red blood cells, leucocytes, and epithelia; also hematoidin, and triple phosphate crystals. Cystoscopic examination revealed normal urine issuing from the right ureter, a bloody fluid from the left. A blood examination made shortly after admission showed 60 per cent. of hemoglobin; less than 3,000,000 red cells; 7800 whites, of which 40 per cent. are mononuclears.

The red cells were not normal; there were some poikilocytosis, a few macro- and micro-cytes, but no nucleated reds. Examination of the fluid obtained by puncture of the mass revealed only red blood cells, leucocytes, and degenerated epithelia. Pulse ranged from 90 to 100, temperature from 99° to 101°.

On June 11 Dr. Kammerer removed the tumor by lumbar incision.

Macroscopically it presents * a large cystic mass, irregularly ovoidal in shape. The surface is smooth, glistening, and white in color, and covered with a network of injected veins. There are surface indications of lobulation. Upon section, the content is found to be a reddish brown, grumous fluid, which shows degenerated leucocytes, red cells, epithelia, numerous cholesterin crystals, and blood pigment. The wall, which seems to be composed of tough, dense, connective tissue, measures from 4 to 16 millimeters in thickness. Incomplete septa partially divide up the cavity of the cyst. The inner surface is smooth and covered with adherent fibrinous masses. Coursing in the wall of the cyst is found the thickened but patent ureter. To all appearances, the tumor is a large monolocular cystlike distension of the kidney, containing much altered blood. Closer examination reveals the presence of two inconspicuous strands of a different tissue, one of which lies in the capsule, the other in one of the septa. Both of these strands are enclosed in a distinct fibrous capsule. Their tissue is firm, their color yellow. On microscopic examination, they are found to be composed of adrenal tumor tissue, presenting the characters of this tissue as it appears after it has undergone malignant degeneration. In some places it is with difficulty distinguishable from cancer, while in others it unmistakably displays the characteristics of the adrenals. The wall proper of the cyst is found to contain the remains of kidney tissue—Malpighian bodies and tubules in a fairly intact condition, imbedded in a large amount of interstitial connective tissue.

The tumor falls, therefore, in the group of hypernephromata. It is differentiated, however, from the great majority of tumors of this class by its remarkable cystic char-

* The tumor, with sections, was shown before the Pathological Society of New York in January, 1905, and is reported in Volume IV of the Proceedings, p. 156.[14]

acter. As is well known, all hypernephromata tend, from a variety of causes, to break down and form cysts. Almost invariably, however, there results a predominantly solid tumor, containing numerous larger or smaller, irregular, cyst-like, cavities; very rarely does the process give rise to the formation of single very large cysts, with hardly discoverable remmants of the tumor tissue in its walls. Nevertheless, a number of other cystic tumors have been described, presenting exactly similar characteristics and with similar hypernephromatous remmants in their walls, so that this—the cyst hypernephroma —must be recognized as one of the pathological varieties of that class of tumors.

The pathogenesis of these cysts seems to me to be a matter of some interest. The occurrence of adrenal tissue in the walls of the cysts seems to indicate with certainty their origin from adrenal "rests," and it might not at first sight seem unreasonable to suppose that their cystic character may simply represnt a further extension of the tendency, so common in hypernephromata, towards cystic degeneration.

On the other hand, they differ very markedly from the typical cystic hypernephromata in the fact that the latter never break down to form single large cystic tumors, but simply contain cystic cavities in the mass of the growth. Indeed, it is difficult to conceive of the complete destruction of the tissue of a hypernephroma, and its substitution by a cyst corresponding to the condition in the cases described. On the other hand, it is easy to see the analogy between these cysts and certain other structures described by W. C. Bosanquet [1] as "cystic adenoma of the adrenal." This author described the following condition: "A round mass lying in front of the left kidney, with the descending colon passing down on the outer side. On removal this proved to be a nearly spherical body, three inches to three and a half inches in diameter, slightly longer in a vertical than in a transverse direction. The left suprarenal was attached to the upper and back part of the tumor, and looked normal." The tumor was found to be a cyst. The cyst wall showed adrenal tissue, and its contents were of the consistency of jelly and

orange colored. There is little doubt, as pointed out by Bosanquet, that the case described by Lockwood [8] is an example of the same condition; he also cites several other cases. It is probable, therefore, that the adrenal rests incorporated in the kidney have gone on, in the cases described in this paper, to the formation of "cystic adenomata" and not of hypernephromata, and have then eventually burst into the pelvis, and induced dilation of the entire organ. All the stages of this process may be traced in the cases which have been reported, starting with that of Leopold (Case VII), and ending with Case I.

With the purpose of establishing the clinical type which characterizes this group of hypernephromata, I have collected all the cases which I could discover in the literature. In all, five cases were found, which closely resembled the present case in their essential pathological features, and in the identification of adrenal tissue in the wall of the cysts. All of these cases, of course, have been reported since the publication of Grawitz's original paper in 1883.

CASE I (GRAWITZ [4]).—The patient, a well nourished man, was observed for ten years. The first symptoms of disease referable to the genito-urinary tract occurred at the age of 40. At this time there were vague urinary symptoms, diagnosed as pyelitis. Seven years later there was hematuria, which lasted a few days, and frequently recurred. The urine showed not only blood, but peculiar papilliferous masses, of which the cells were large and ovoidal, so that the diagnosis of carcinoma of the bladder was made. The patient, however, became better again, and only two years later observed a swelling in the left side of abdomen. This tumor continued to grow, and finally after two more years produced pressure symptoms. The latter were relieved on three successive occasions by puncture, the last of which set up a suppuration. The puncture fluid was chocolate-brown in color, cloudy, and contained many cholesterin crystals.

The autopsy, by Grawitz, disclosed a tumor mass in the left side of the abdomen, measuring 25 x 20 cm. The tumor proved to be a degenerated left kidney, transformed into an enormous monolocular cyst. The wall of the cyst showed remnants of kidney tissue, and remains of a whitish, crumbly tissue, which represented all that remained of the hypernephroma. There were three adrenal tumors in the opposite kidney.

CASE II (STRÜBING [10]).—In a patient, male, aged 67, a tumor of the abdomen was accidentally discovered. Tumor was clinically diagnosed to be cystic, derived from right kidney. General condition very good. Pres-

sure symptoms involved the gastric and respiratory functions; and there was œdema of legs. The cyst was observed for four years to gradually increase in size. Hematuria never occurred. Remarkable is the absence of hematuria, in spite of patency of connection between cyst and ureter. Finally puncture was indicated to relieve the pressure symptoms, and evacuated 3 liters of a chocolate-brown fluid, mixed with fat and cholesterin. After a brief period of improvement, the cyst again began to grow rapidly, owing, as the autopsy showed, to hemorrhage, and the patient died from asthenia.

Autopsy.—A cystic tumor in right side of abdomen, measuring 22 x 24 x 26 cm. Contained 5 to 6 liters of dark, chocolate-brown, fluid; cholesterin crystals present. Cyst is composed of right kidney. Wall shows remnants of kidney tissue; pelvis and calices dilated; ureter enters cyst. Wall of cyst 4-5 mm. thick. The inner surface presents numerous nodules, ranging in size from pea to twice that of a walnut, whitish yellow in section. Wall microscopically composed of dense connective tissue. The small tumors consist of polygonal, epithelioid cells, with much fat contents. The diagnosis of hypernephroma was made from sections of these tumors. The left adrenal was normal.

Case III (Strübing[10]).—A woman, aged 64, who had always been strong and healthy, had a sudden attack of pain in the left side. The pain lasted only a few days, but was followed by a period of irregular fever (37.2–38.8) and digestive disturbances. Examination disclosed a tumor of the size of a fist in the left hypochondrium. It was rounded, soft, not tender. It did not move with respiration. Tympany over the anterior surface. Urine normal. During the following three weeks, the tumor became larger and fluctuating; it reached the navel, and extended two fingers below the anterior spine. Fever persisted. Right pleurisy.

The case was diagnosed as a paranephritic abscess.

Lateral incision, for the purpose of drainage. Incision evacuated 1 liter of dark, bloody, fluid, containing large shreds of softened tissue. The tumor proved to be a large cyst. Suppuration followed, with pulmonary involvement, and death. The cyst was removed post-mortem and sent to Dr. Grawitz, who made the diagnosis of hypernephroma. The microscopic appearance was practically the same as that in the preceding case.

Case IV (Villaret[13]).—The clinical data are very inadequate. It is stated only that there were pressure symptoms from the tumor, but nothing referable to the urinary tract. The kidney was removed at operation, and came to the hands of Prof. Grawitz. The mass consisted of a sac, about as large as a man's head, the walls of which present soft tumor masses. At one point, kidney tissue is recognizable. The contents consist of a blood-stained fluid, containing masses of tissue in fatty degeneration, and much cholesterin. The wall shows remnants of kidney tissue, and adrenal tissue.

Case V (Pirone[9]).—A man of 40, previously healthy, began in January to have pains in the left side. At the same time a tumor made its appearance, and gradually increased in size. Three or four months later,

the patient observed blood and clots in the urine. The clinical diagnosis was sarcoma of the left kidney. Extraperitoneal nephrectomy was done in June, 1902. At operation the mass was found to be fluctuating, and an exploratory puncture yielded about 100 cc. of a thick reddish brown liquid, containing granular material. Incision over the site of puncture yielded 150 cc. of detritus.

In addition to the five cases above detailed, in which adrenal tissue was identified in the wall of the cyst, the literature contains mention of a large number of other cases in which there is little doubt that the origin of the cysts was due to an unidentified hypernephroma of this type. These cases are not specifically referred to in the bibliography. A considerable number of them may be found in the article by Strübing who is, however, certainly somewhat too liberal in his interpretation of the pathology of certain of these doubtful cases. Two of these cases are of sufficient interest to demand detailed presentation.

CASE VI (SCHETELIG[11]).—Patient is said to have had an enlarged abdomen from birth. This gradually increased in size up to the seventh year, when she had a severe fall. This was followed by a severe abdominal pain, and the passage of considerable quantities of bloody urine. This polyuria continued for three months and was associated with gradual decrease in the size of the abdominal tumor. The latter then gradually resumed its former size. At the age of ten the same thing recurred—a fall, hematuria, polyuria, decrease in size of tumor, and subsequent growth. Status praesens: a healthy looking young woman (age not given). Urine normal. Abdomen measures 122 cm. in its greatest diameter. A smooth, tense, movable tumor can be felt, apparently occupying the entire left half of the abdomen, and extending beyond the middle line to the right anterior superior spine. At operation, a median incision was made. The cyst was punctured, and 30 "pounds" of fluid evacuated. The fluid was rather dark in color, of a specific gravity of 1018, and contained large amounts of cholesterin. The patient recovered, but returned after three months with the abdomen again much swollen. A diagnosis was made of ovarian cyst, and the cyst was now extirpated by Esmarch.

The cyst was examined by Cohnheim. It measured more than one foot in diameter. The wall was composed of thick, leathery, whitish yellow membrane, almost ½ cm. in thickness. Here and there, it was studded with numerous smooth, whitish elevations, some of which were calcified in parts. The ureter was found running in the wall of the sac. There was no obstruction.

CASE VII (LEOPOLD[7]).—Woman, age 33. Has observed a swelling of the abdomen for five years. The objective signs were those of an enormous ovarian cystoma. An operation was done to extirpate this, and, upon removal, the following condition was found. The cyst was "the size of a man's head" and was found to be attached to the lower pole of a somewhat compressed right kidney. The kidney pelvis was quite intact, and the cyst nowhere communicated with it. The capsule of the kidney was continuous with that of the cyst. The content was bloody and contained much hematoidin. The origin of the cyst is held by Leopold to be doubtful.

If the present case be compared in its clinical features with the great majority of hypernephromata, it will be found to present certain peculiar characters of its own. Briefly, the hypernephromata, as a group, occur in middle life, they grow slowly, rarely, however, running for more than three years, their course may be marked by repeated attacks of sharp hæmaturia of brief duration; in most of the cases, metastases are a marked feature. Peculiar to the cyst-hypernephromata, as seen both in the case above described and in the other cases collated from the literature, are the clinical signs of a cystic, instead of a solid tumor of the abdomen; the prolonged period of growth,—in the case herein reported, over 40 years, if the first hæmaturia be counted, and five years during the second stage of growth; the character of the hæmaturias, which were very largely *on the presence or absence of hæmaturia.* In the the absence or very late occurrence of metastases; and the presence of pressure symptoms from the stomach, or other abdominal viscera, due to the large size of the cystic growth. This group of symptoms, if at all constant, would seem to afford a sufficiently characteristic syndrome. As regards the character of the urine, this is entirely determined by the anatomical relations of the tumor. It is a matter of great clinical importance, whether the cysts breaks into the pelvis of the kidney and forms one large cavity with it, which constantly discharges its contents into the ureter; or whether it intermittently discharges its contents into the ureter, a phenomenon characterized by an intermittent hæmaturia, as in the present case; or whether it causes lateral compression of

the ureter, with retention of the cyst contents as in Case II; or whether it remains permanently separated, causing no urinary symptoms whatever as in Case VII.

If, now, the diagnosis of these tumors be considered, it is evident that they must be grouped, in the first place, among the intra-abdominal cysts. Further differentiation depends very largely *on the presence or absence of hæmaturia.* In the latter cases, the differential diagnosis from ovarian and other forms of cysts must be made largely from the location, the relation to the colon, and the other criteria upon which reliance is generally placed. Cases of this type have been confused with ovarian cyst and paranephritic abscess. If puncture of the cyst be made, a procedure of a very questionable character, the nature of the cyst fluid, which is uniformly rich in cholesterin and blood pigment, might be allowed to weigh heavily in favor of the diagnosis of cyst hypernephroma. In the former group of cases, the presence of hæmaturia, combined with the cystoscopic findings, make it a very simple matter to identify the renal origin of the tumor. In this case, therefore, the differential diagnosis must concern itself with all other forms of cysts, or cyst-like dilatations, of the kidney or pelvis associated with hæmaturia. If certain salient characters of the cyst hypernephromata—their prolonged course, their comparatively benign character, the absence of colic, their characteristic content of cholesterin and blood—be kept in mind, this diagnosis will rarely present great difficulties.

First to be considered is renal tuberculosis. Ordinarily, this produces only slight enlargment of the organ, perhaps to double its size; in another set of cases, it gives rise to large cyst-like dilatations, which may simulate an abdominal cystic tumor. The latter condition is due to intermittent or permanent obstruction of the ureter, either by stricture, or by caseous masses, resulting in a tuberculous pyonephrosis. At the same time, renal tuberculosis may produce recurrent hæmaturia, with emaciation, and anæmia, and so imitate in the most striking fashion the hypernephric cysts. There are generally marked vesical symptoms, such as frequent urination, and

cystoscopic examination may then reveal ulcerations or other tuberculous lesions of the bladder. The presence of tubercle bacilli in the urine, the finding of other tuberculous lesions, especially in the genito-urinary tract, the positive tuberculin reaction, are all diagnostic aids which should, of course, be sought for in all doubtful cases.

Cancer and sarcoma of the kidney may, likewise, if associated with obstruction of the ureter, give rise to a cystic tumor of the abdomen combined with hæmaturia. This is certainly a comparatively rare condition, but has been repeatedly described. The pathological differentiation between carcinoma, and even sarcoma, and the suprarenal tumors, is a matter of such recent date, and even now frequently so difficult, that it is not unfair to doubt the actual nature of certain of the tumors grouped in the former category. The combination of malignant tumor in the kidney with ureteral obstruction by means of its growth, or by metastases, does, however, occur, and its differentiation from the tumors under consideration might offer certain difficulties. With the former class of tumors, the period of growth is, however, rarely so prolonged, and the cachexia generally far greater.

Calculi with partial or complete obstruction of the ureter may also give rise to recurrent hæmorrhages, and to large cystic tumors of the abdomen. The character of the urine, and the history of colic ought in these cases to render the diagnosis a matter of no great difficulty.

Tuberculosis of the ureter, new growths of the bladder obstructing the ureteral orifice, and other conditions which might simulate the symptoms of cystic hypernephromata are rare, and as a rule easily identified.

The indications for treatment are quite evident from the recital of the cases on record. The tumor is not very malignant. It is a source of danger, in the first place, as a cause of hæmorrhages and anæmia, and, in the second place, on account of the pressure symptoms which it induces in the neighboring viscera. Metastases occur, if at all, only late in the disease. Its removal is generally a simple matter and offers a radical

cure. This course should, therefore, be followed in every case in which the operation is not contraindicated by the age or condition of the patient. Drainage, or repeated tapping of the cyst should never be resorted to, as these measures are not only ineffectual, but have precipitated a fatal outcome in every case in which they have been employed.

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THE EXTENSION OF THE FIELD OF TREATMENT OF CERTAIN RENAL AND VESICAL CONDITIONS THAT IS MADE AVAILABLE BY A NEW CONTRIVANCE FOR LONG CONTINUED OR PERMANENT DRAINAGE OF THE KIDNEYS THROUGH RENAL FISTULA IN THE LOIN.*

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If life could be made not only tolerable but comfortable for persons with long standing or permanent renal fistula, in what respects would this fact modify or enlarge the field of treatment of cases of renal and vesical disease?

In the writer's belief the following advantages would be derived: 1. Primarily we should be enabled to save a good many kidneys which we are now accustomed to sacrifice in order to spare the patients the distress arising from the presence of a renal fistula. Thereby we should at the same time, of course, avoid the dangers, whatever they may be, attending the performance of nephrectomy and such subsequent ones as are involved in the fact of having but one kidney.

Further than this we should be enabled to carry out certain new plans of treatment which have hitherto not been available because of the fear of creating a permanent and distressing fistula. With this end in view, the writer proposes the simultaneous performance of bilateral nephrostomy, tying off of both ureters at the same time and establishing permanent renal fistulæ, thus wholly diverting the entrance of all urine into the bladder, for the following purposes:

1. *As a palliative measure.*—(*a*) In cases of inoperable vesical tumor. (*b*) In cases of vesical tuberculosis originat-

* Read at the meeting of the American Gynecological Society and American Association of Genito-Urinary Surgeons, May 9, 1907.

ing in descending infection, in which both kidneys are involved in the tuberculous process and when the tuberculous lesions of the bladder are causing suffering. In the latter condition also there might be expected to be better results obtained from the local treatment of the vesical tuberculous lesions.

2. *As a step preliminary to the total extirpation of the bladder in certain cases of vesical tumor.*—This proposal was made by the writer at the Montreal meeting of this Association in 1905 and published in the December number of the ANNALS OF SURGERY of the same year. It is referred to again now merely to reaffirm the writer's position with regard to it, which has been strengthened with respect to one of its features by the practical experience of three cases in which he has simultaneously performed bilateral nephrostomy and which have supported his contention that shock was not an element to be dreaded from the performance of the operation upon the two kidneys at the same time. The proposal was as follows:

That instead of doing ureteral implantation in connection with partial resections or total extirpations of the bladder in cases of tumor of that organ, the procedure be wholly abandoned, and that simultaneously performed bilateral lumbar nephrostomy be substituted for it, and that it be done as a step preliminary to the removal of the bladder, the latter intervention being carried out afterwards at periods which will vary according to the conditions existing in each case. That this course be pursued in cases of carcinoma of the bladder in which *any* radical operation is proper to do, and to recurrent tumors following the removal of benign neoplasms, if there is any reason to believe the recurrent growth to be of malignant nature.

The success of these measures must depend in large degree upon the possibility of arranging the drainage from the kidneys after the lumbar nephrostomies in such manner as to be comfortable, and thus to be secure of avoiding the creation of a condition as intolerable in its way as that for the relief of which it was undertaken.

This object the writer believes he has attained by a very

simple contrivance which he has devised, whereby that feature of renal fistula which is the one which causes it to be such an infirmity, is entirely overcome. The greatest trials of renal fistula are the constant soaking of the clothing and dressings with urine, and the unpleasant odor which emanates from them. The contrivance designed by the writer keeps the patient perfectly dry, and can be worn without attracting attention and with entire comfort. It is composed as follows:

1. A hard rubber cup-shaped shield through which the tube that enters and drains the kidney is passed (fig. 1).

2. A light metal receptacle into which the urine is conveyed (fig. 2).

3. A rubber tube attached to the bottom of the receptacle by means of which the latter is emptied (fig. 2*a*).

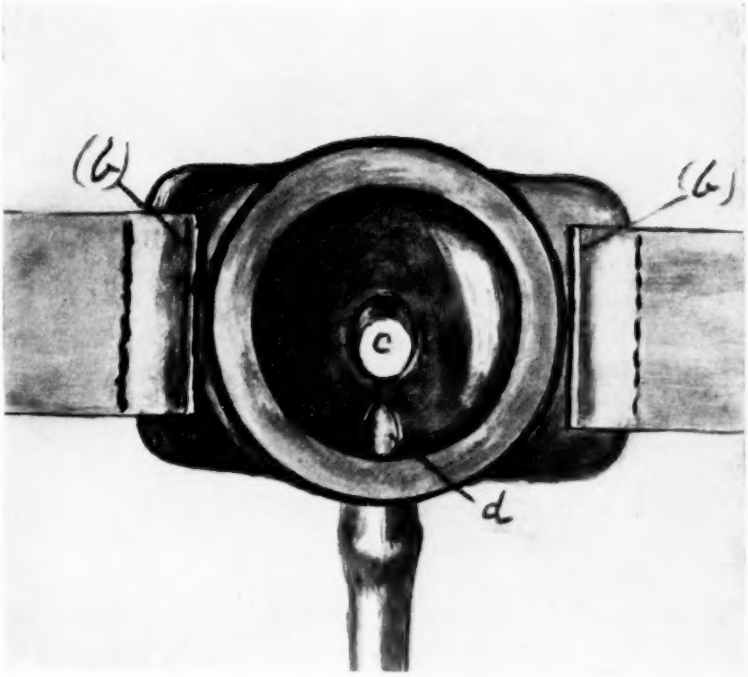
4. Two elastic bands or belts one inch in width which pass around the body and by which the shield and the receptacle for the urine are held in place (fig. 3, *a* and *b*).

1. *The Shield.*—The shield is made up of a circular, cup-shaped, central part, and two side wings. The former is perforated by two holes (fig. 1, *c* and *d*), one of them passing through its centre and having a downward slant in its course through the shield in order to avoid being obliged to give the kidney drainage tube a sharp bend and thus narrow it as it passes down to the receptacle. The second hole is just within the inner margin of the rim of the circular part of the shield and at the lowest point in the circumference when the shield is in place upon the surface of the back. The purpose of this hole is to drain the cup of the shield, which it does by the smaller of the two tubes which pass to the receptacle (fig. 4, *a*).

The cup of the shield catches whatever urine leaks around the outer sides of the kidney drainage tube, and this leakage is at once passed into the can in the manner already mentioned.

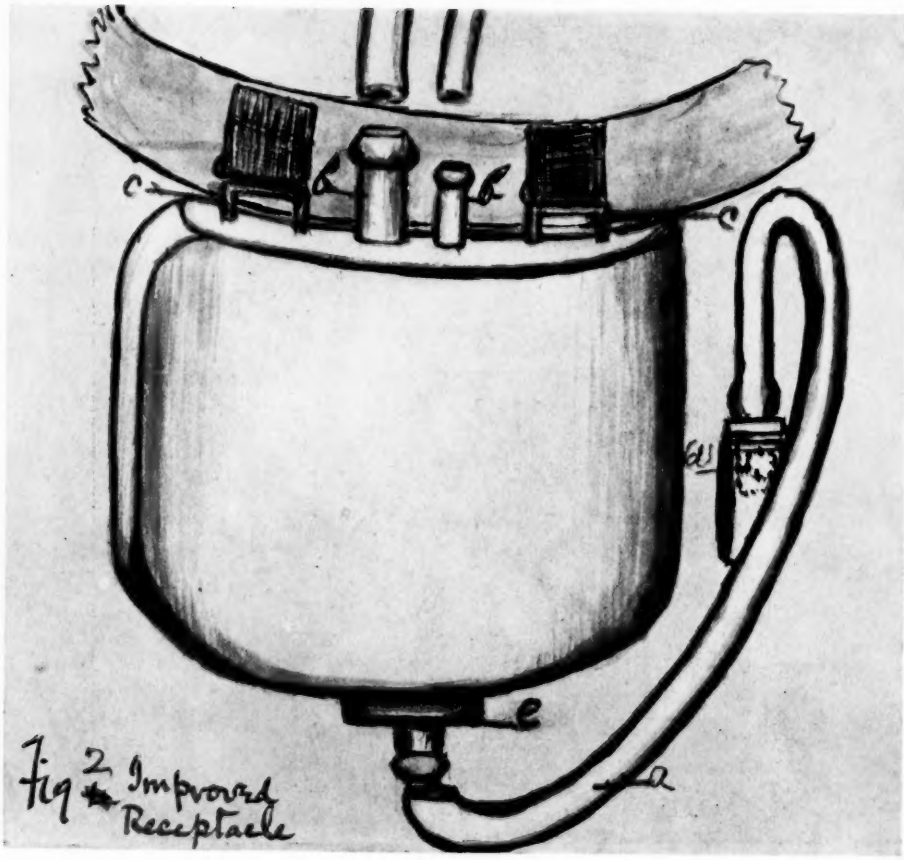
Elastic bands one inch in width are passed through the openings in the wings of the shield and are thus attached to it (fig. 1, *b* and *b*), and being passed around the body and buckled in front, form the belt by which the shield is constantly held close upon the surface of the loin.

FIG. 1.



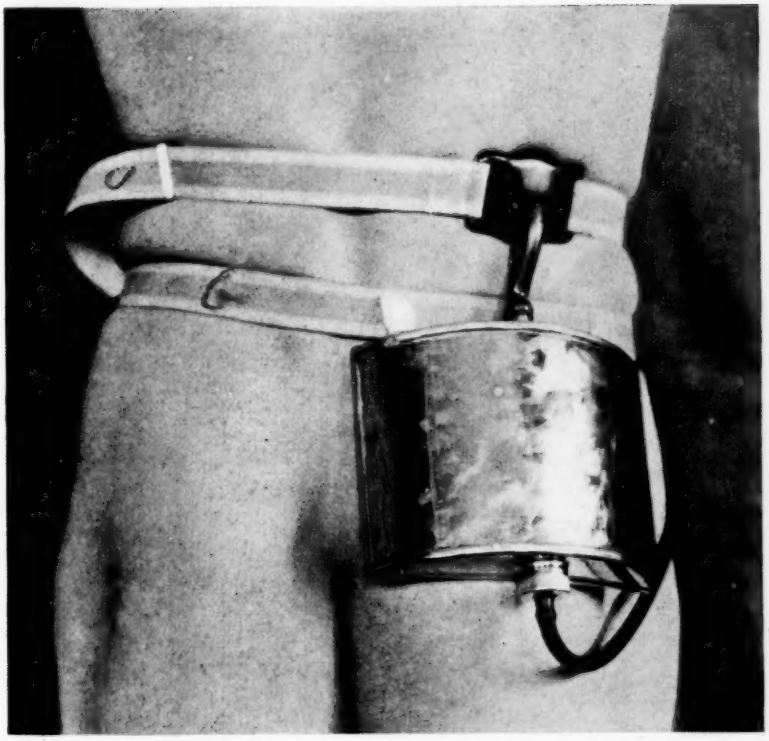
The shield with the elastic bands attached and the tube which drains the shield.

FIG. 2.



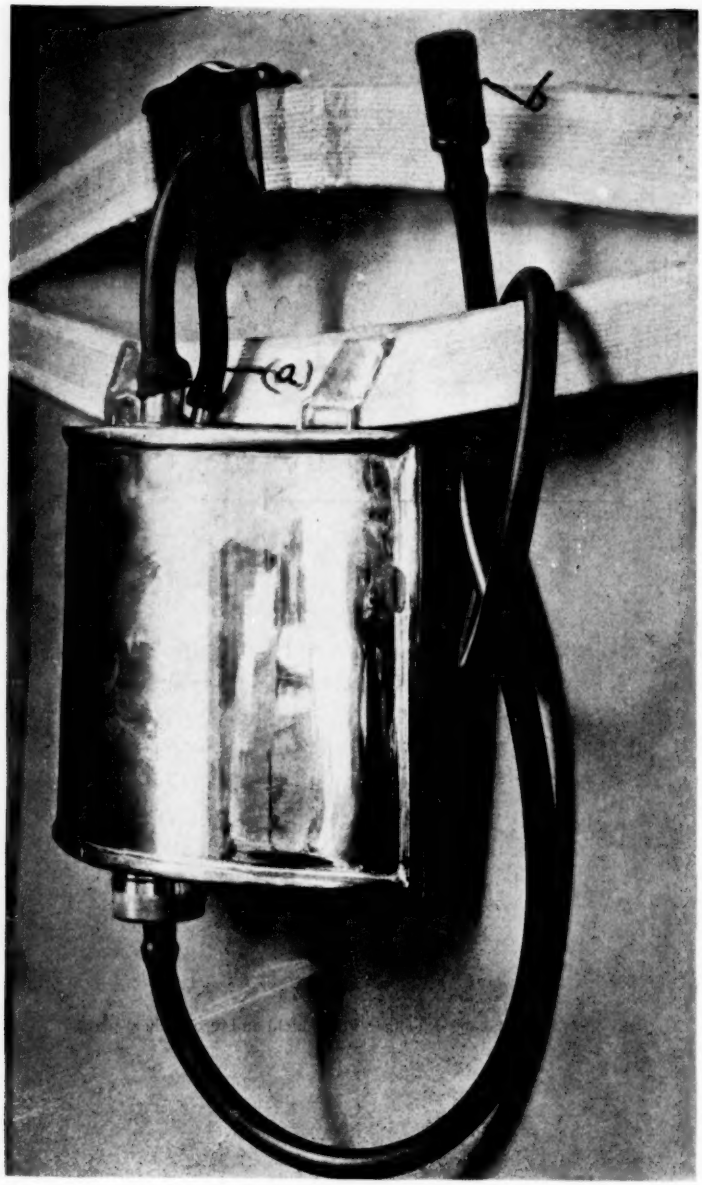
Improved receptacle.

FIG. 3.



(*a*) and (*b*) are the elastic belts to keep shield and receptacle in place.

FIG. 4.



The shield-receptacle with their tubes and belts attached to them, and strapped to a board to show the individual parts of the apparatus. (*a*) tube which drains the cup of the shield.

The tube draining the kidney directly, and which passes through the hole in the centre of the shield, must be one or two sizes larger than the hole, in order that it shall bind firmly against the sides of it, and thus be prevented from changing its position to or fro, and pressing injuriously on the kidney on the one hand, or being withdrawn too far to efficiently drain it on the other.

The tube draining the cup is to be fitted over the end of the smaller of the two metal tubes which are placed in the middle of the upper surface of the receptacle, and in this way the junction between the cup of the shield and the receptacle is effected. The main drainage tube from the kidney is passed in the same way over the end of the larger metal tube of the receptacle, or if the drainage tube is too small to allow this to be done, it can be passed *into* the metal tube instead.

The calibre of the central hole in the shield is about 28 of the Charrière scale. If the kidney drainage tube is in any case so small that it will not bind in the hole, its calibre at that point can be sufficiently increased by passing over it a second bit of tubing just where it traverses the hole.

It is important to adjust the kidney drainage tube at the spot within the kidney at which its end drains the organ most effectively and at the same time causes the patient no discomfort. Once this has been determined, a mark should be made upon the catheter or drain just where it emerges from the outer side of the shield, in order that time shall not be wasted in re-adjusting the tube each time that it is introduced.

The tubes and all parts of the apparatus except the shield and the belts should be boiled in water once each day.

2. *The receptacle* (fig. 2).—The receptacle is a can made of German silver, curved to fit the upper part of the gluteal region and provided with the following things. Upon the middle of its upper end are two short metal tubes (fig. 2, *b* and *b*), upon the larger of which the main kidney drainage tube is attached. The smaller one receives the end of the tube which drains the cup of the shield. Two pieces of bent wire (fig. 2, *c* and *c*) set into the inner edge of the receptacle to

which the elastic belt is attached which keeps the can in place. A metal cap (fig. 2, *c*) in the middle of the bottom of the can which unscrews and allows it to be more readily cleaned.

3. *The tube for draining the receptacle* (fig. 2, *a*).—A tube, a foot and a half to two feet long, is attached to the screw cap in the bottom of the can and is led round to the front of the body, where it is tucked under the belt and its end brought over it and allowed to hang downward. The further end of this tube is provided with a hard rubber cap (fig. 4, *b*), one end of which has the form of a stem which slips into the rubber tube. In this stem is a hole (fig. 2, *d*). The hole is closed by the hard rubber cap when it is screwed home against the shoulder which is just behind the hole, while when the cap is screwed outward in the other direction, the hole is uncovered and allows the contents of the can to escape through it. The capacity of the can is about ten ounces, and consequently it does not require to be emptied more than two or three times daily. When it is desired to do this, the tube which drains the can is taken from beneath the belt in front and the hole just described at its end being opened, the can is evacuated of its contents. The hole is then closed and the tube replaced. By this contrivance the patient is spared the trouble of detaching any parts of the apparatus from each other during the entire day.

THE MANNER OF ARRANGING THE DRAINAGE AT NIGHT.

At night the can is detached and long tubes are substituted for the ones which drain the shield and the kidney. The two tubes are led to a bottle which is fastened to the side of the bed and the drainage is received by that during the night.

A semi-reclining position ensures better drainage than if the patient lies quite flat. The receptacle can be attached nearer or further away from the shield or can be carried slightly to one or the other side of it—corresponding changes being made in the length of the tubes—as the patient may find to be most convenient and comfortable. Fig 3 shows the apparatus in position with the tube which drains the can passed around the body to be placed under the belt in front. The

essentials of the receptacle are that it shall be light, fitted to the surface upon which it lies, its capacity sufficient to avoid the necessity of emptying it too often and of such a character that it can be readily cleaned. The shield is given a very slight curve in order that it may adapt itself more completely to the surface of the body, and thus insure the cup fitting tight and not leaking.

The object aimed at in this contrivance is to keep the patient dry, the failure to do this hitherto has been the one distressing feature of renal fistula. It is owing to this feature that individuals with renal fistula have been wholly disabled and practically isolated from their fellows because of the unpleasant odor arising from that source.

A receptacle is of course essential to the contrivance, but it may be varied almost indefinitely with respect to size, shape, and the place in which it is worn on the body and also as to the material of which it is made. The writer has one patient who wears for the receptacle, the usual form of rubber portable urinal bag attached to the thigh, and another who wears the metal can on the back. The advantage of the metal can is that it can be boiled as often and as long as one likes, has no odor; moreover it is easier to arrange the receiving and emptying tubes on a metal than on a rubber reservoir. The prime essential of the contrivance is the shield. It is that which keeps the patient dry and which keeps the tube in its proper place in the kidney where it will most efficiently drain the organ, and the essential features of the shield are its cup-shaped centre and the hole and tube which drain this cup. It is well to note the following things with regard to the shield:

In some cases there will be a furrow made by the cicatrizing of the wound through which the fistula passes and along the line of this furrow, the shield may fail to be held firmly against the surface and urine would then escape from the cup. The same may be true if the incision is made parallel with the lower border of the last rib, for the shield may then rest on one of its edges upon the surface over the rib and the other on the softer tissues. This fact together with the respiratory movements of the ribs might very likely displace it

enough to allow the urine to escape from the cup elsewhere than through the hole designed to drain it. Again some patients may find the pressure of the hard rubber rim of the cup uncomfortable. To obviate these difficulties, the rim of the cup may be made a little wider and a channel with overhanging edges cut in it, into which a ring or tube of soft rubber can be snapped and held by the undercut edges of the channel. The soft rubber will adapt itself to the irregularities. of the surface, and may be advantageous in some instances. In case of the existence of a deep furrow in the line of the cicatrix which must be filled up to prevent the fluid from escaping from the cup, the rubber ring can be enlarged somewhat at that point in order to adapt itself to the surface. As a matter of fact, the skin of the immediately adjacent soft parts will usually bulge into such a depression when the shield is pressed hard against the surface and will fill it sufficiently to prevent leakage.

The writer has had this device in use with entire success in two instances. In one of them a little change in the adjustment and the size of the cup of the shield was required before it worked properly. The contrivance can be equally well applied, of course, to fistulous openings of transplanted ureters and other similar conditions connected with the different organs of the body, with which fistula is connected. This apparatus is made by Rodman and Shurtleff, 120 Boylston Street, Boston.

One word with regard to the advantages of nephrostomy as compared to ureteral implantation. The latter is open to the serious objection that it frequently invites renal infection because of contraction of the implanted orifice of the ureter or of the ureter itself at some point between the orifice and the renal pelvis, and, in case of intestinal implantation, because of its being a septic locality. The following tables show what the results of ureteral implantation were found to be in 94 cases. The operative mortality for the whole series was 41.4 per cent.; 23.4 per cent, was directly due to ureteral implantation. The conditions in which the implantations were done are as follows:

I

Vesical Tumors.	Cases.	Operative. Deaths.	Causes of Death.	Later Deaths.
Suprapubic not resections	11	0	.....	2. One to ureteral contraction ..... 1 Not stated.
Partial resect.....	23	11	Ren. infect..... 3 Shock ..... 4 Infilt. of urine .. 2 Peritonitis..... 2	
Total extirp.....	38	19	Ren. infect .....10 Shock ..... 9 Pneumonia 1	3. Ren. inf..... 2 Recurrence 1
Ureter cut in abdom. operations	22	9	Ren. infect..... 6	
	94	39		

Cases, 94; operative deaths, 39 or 41.4 per cent. Due to ureteral implantation, 22 or 23.4 per cent. mortality.

These cases in detail are as follows:

II

TOTAL EXTIRPATION OF THE BLADDER—38 CASES.

Treatment of Ureters.	Operative. Recovered.	Operative. Deaths.	Causes of Death.	Due to Ureteral Implantation.	Later Deaths and Causes of.
Abandoned in wound ...	2	2	Renal infect .... 1 Shock 1	1	
Sutured into intestine ...	5	10	Renal infect .... 5 Shock ..... 4 No data 1	5	1 at 3½ months, renal infect. 1 at 14 months, no data.
Sutured to skin	3	1	Renal infect 1	1	1 at 13 months, renal infect. 1 at 6 months. Recurrence.
Sutured into vagina.....	3	2	Renal infect .... 1 Shock 1	1	
Sutured to urethra.....	1	4	Renal infect .... 2 Shock 2	2	
	14	19	19	10	4

Without data..... 5
Total number 38
Deaths due to ureteral implantation..... ... 10

OPERATORS REPORTING THE ABOVE CASES.

Bardenheuer..... 2	Viljaminow 1	Kayser 1
Pawlik 1	Bergenhem..... 1	Lund..... 1
Albarran..... 1	Mann 1	Mayo Robson 1
Modlinski..... 3	Verhoogen 1	Gopel 1
Kuster 1	Vaughan..... 1	Harris..... 1
Wassilief..... 1	Woolsey..... 1	Tuffier..... 1
McCosh 2	Schede 1	Lindner 1
Giordano 2	Turetta 1	Zeller 1
Chalot..... 1	Hogge 1	Garre 2
Kossinski 1	Krause 1	Wendel..... ... 1
Kummel..... 1		

III

PARTIAL RESECTIONS—23 CASES.

Treatment of Ureters.	Operative. Recoveries.	Operative. Deaths.	Causes of Death.		Due to Ureteral Implantation.
Implanted into bladder	12	9	Shock	4	
			Renal infect.....	2	2
			Infiltration of urine.....	2	2
			Peritonitis.....	1	
				9	4
Abandoned in the wound	0	2	Peritonitis.....	1	
	12	11	Cellulitis	1	1
				2	5

Total, 23; deaths, 11. 47.8 per cent.

Deaths due to ureteral implantation, 5. 45.4 per cent. of deaths due to ureteral implantation.

	Cases.
Israel.....	2
Czerny.....	5
Albarran	2
Bardenheuer	2
Schuchard.....	1
Helferich	1
Giordano.....	1
Schilling	1
Verhoogen	1
Rafin	1
Rehn	1
Kuster.....	1
Mickulicz	2
Berg.....	1
Vincini.....	1
Total	23

Implantation into bladder, 21; abandoned in wound, 2.

III.

VESICAL TUMOR.
OPERATIONS OTHER THAN PARTIAL RESECTION OR TOTAL EXTIRPATION.

Cases II. Deaths 0. Later 2.

Implantations into bladder 2. Later deaths 2. Due to ureteral implantation in one perhaps, not so in the other.

In 7 other cases there was an opportunity to test the patency of the ureter at various times subsequent to the operation. In one of these the ureter was apparently obliterated and the kidney was believed to have undergone atrophy. The patient was, however, in good health.

Operators in these cases were: Routier, Pernice, Krug (case observed 8 years after operation), Kalabin, Rafin, Wertheim, and Frantz (5 cases).

With direct drainage of the kidney through the loin, on the other hand, the objection which has been brought by the writer against ureteral implantation, does not hold good, provided the drainage is thorough and thoroughly maintained, if ordinarly good care be taken of it, and the fistula prevented from recontracting. There is moreover the further advantage that nephrostomy and free drainage of the kidney directly through the loin is by far the best treatment that can be applied to cases of infected kidneys with suppuration, and to many of hydronephrosis, for which ureteral implantation is ineffectual, and in some instances actually invites an increase sooner or later of the malady. Furthermore, in such conditions, ureteral implantation gives no opportunity to explore the interior of the kidney, remove calculi, or break down partitions separating abscess cavities and so on, which nephrostomy does afford. Finally the mortality attending incision and drainage of the kidney is, per se, very small. While the contrary as has been shown is true of ureteral implantation.

It will be remembered that in the series of cases given above in which that procedure was carried out, death was caused by it in 23.4 per cent.

It is difficult to get an exact idea of the mortality of nephrostomy as an operation and the same is true of ureteral implantation, because of the serious conditions under which or in connection with which the two procedures respectively are done. The nearest approach that can be made to determining the operative mortality of each is by a comparison of the results of Maydl's operation with those of nephrostomy when done in cases of non-infected kidneys. Of 42 cases of Maydl's procedure for ectopia, 9 ended fatally or 21.4 per cent. (3 of the deaths or 7.1 per cent. were directly due to ureteral implantation). In 143 cases of hydronephrosis there were but 5 deaths following nephrostomy or 3.4 per cent. In 77 nephrostomies reported by Albarran, done for various conditions, there were 3 deaths or 3.7 per cent. mortality.

UPON CERTAIN ASPECTS OF CALCULOUS ANURIA WITH ESPECIAL REFERENCE TO THE PERFORMANCE OF BILATERAL NEPHROLITHOTOMY SIMULTANEOUSLY IN SOME CASES OF THIS CONDITION.*

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If in a case of calculous anuria one kidney is laid open and a stone is removed from it or from its ureter and it is then seen that that kidney's secreting substance has been wholly destroyed, it is clear that the operation will have merely added more or less shock to the already critical condition of the patient without having secured any compensating advantage whatsoever. Equally is it obvious that whatever there may have been of renal functional activity possessed by the individual before the occurrence of anuria, must have resided in the other kidney, and it is evident that the only hope of saving life under such circumstances lies in immediately cutting into that opposite kidney, since only by so doing can we set free its suppressed function, this suppression being the factor which will cause death if it is not overcome within a short time.

Now, if instead of being wholly destroyed, the kidney first operated upon was seen to be in greater or less degree diseased, the logical inference would be that in degree inverse to the extent of disease and functional incapability of this kidney, the other one would be found to be more or less free from disease and more or less functionally capable. In other words, the worse the condition of the first kidney, the better may we expect to find that of the other one, and vice versa.

It is as we all know, impossible to determine from the thickness or thinness of the layer of renal substance that such

* Read at the meeting of the American Gynecological Society and the American Association of Genito-Urinary Surgeons, May 9, 1907.

kidneys are seen to possess at the time of operation, just what amount of functional activity may be left to them, but we can give a pretty good guess at it, and if in our judgment, it is very doubtful if the first kidney opened has enough sound secreting substance to enable it alone to sustain life, we should, in the writer's belief, at once operate upon the other kidney. In so doing, we may, it is true, fail to save the patient's life, but we shall have given him his best and often his only chance of life by putting in commission again all the available functionally active renal substances that he possesses.

If on the contrary, the first kidney has a goodly amount of renal substance which is apparently free from disease, the indication *not* to operate upon the second kidney would be equally clear, since the better the condition of the first one, the less likely will it be that there is any functional value in the second one, and correspondingly the less the advantage to be gained from operating upon it.

The above propositions appear to be simple and logical, and so obviously true, that it would scarcely seem worth while to present them, were it not for the fact, so far as the writer can learn, that he is the only surgeon who has acted upon them.

The question which arises when considering these propositions is how often, if at all, are the conditions just stated likely to be encountered.

In calculous anuria, apart from those instances in which the condition is brought about by anomalies of the kidneys or ureters, one of the three following things is generally stated to be the causal factor: (1) The simultaneous blocking of both ureters by calculi of both sides. (2) The blocking of one ureter, the other kidney being absent. (3) The blocking of one ureter, the other kidney being so far diseased or destroyed as to be functionally useless.

The suppression of the function of a normal kidney with an unobstructed ureter, by reflex influence, originating in the blocking of the ureter of its fellow organ on the other side, is denied by many observers. In parenthesis it may be said that there are very few cases in which the occurrence of this phe-

OPERATIONS DONE IN CASES OF BILATERAL CALCULUS.

Operations.	Cases.	Nature of Operations.	Results.	Remarks
Chevalier.....	1	Unilateral nephrotomy	R	Anuria of 14 days preceded operation.
Championnier....	1	Unilateral nephrolithotomy	R	Same for 13 days.
Deaver.....	1	Nephrolithotomy on one kidney. 18 days later nephrectomy on same kidney. 9 months later nephrolithotomy on other kidney.	R	
Deansley.....	3	(1) Nephrolithotomy on one kidney. 2 week later same on other kidney.	R	
		(2) Unilateral nephrolithot. No operation on other kidney.	R	
		(3) The same.	R	
Desnos.....	1	Unilateral nephrolithot.	R	Anuria 12 days preceding operation.
Duret.....	1	Unilateral nephrolithot.	R	Same 10 days.
Delbet.....	1	Unilateral nephrolithot. Second kidney same one year later.	R	Hydronephrosis of first—pyonephrosis of second.
Kummel.....	16	5 with anuria — Unilateral nephrolithotomy.	3 D 2 R	
		11 without anuria, same operation with second kidney done after an interval in each case.	9 R 4 D	
Grohe.....	1	Unilateral nephrolith on one kidney and same on other after 15 days.	R	
Mixter.....	1	Same—second kidney done six months later.	R	
Tuffier.....	1	Same and later, at two intervals, same on second kidney.	R	
Verdi.....	1	Same. Calculus passed. Spontaneously from other.	R	
Watson.....	2	Simultaneous bilateral nephrolithotomy in both.	1 D 1 R	Anuria in fatal case See illustrative cases.
Young.....	1	Unilateral nephrolithot.	1 D	See illustrative cases.

Total 32, Deaths 9=27.9 per cent.

nomenon has been demonstrated. Four cases at least are well authenticated however.

But comparatively little mention is made of the not very common, but still very important cases, in which the suppression of the function of the unobstructed kidney takes place because of the calculous obstruction of its fellow when the unobstructed organ is in varying degrees diseased or disabled in its functional capability, but not wholly destroyed, possessing a lessened but by no means unimportant functional power could it be set free.

With regard to the frequency of bilateral calculus, we have realized since the use of X-ray photography that these cases are much more frequent than had previously been supposed. They may be estimated at 30 per cent. of the total number of cases of renal calculus. This estimate is based upon the reports of 231 cases of renal calculus made by Albarran, Legueu, Morris, Kummel, and Kraft. The first two place the number as high as 50 per cent., Morris as low as 10 per cent., but the average in the 231 cases referred to was 30 per cent.

Now if we put together all the cases of bilateral calculus, those in which the unobstructed kidney when it is more or less diseased and has had its function suppressed by reflex influence, but in which it is by no means incapable, and the small contingent in which the surgeon may have operated by mistake upon the most damaged of the two organs instead of the least injured one, there is a considerable number in which, if the operator rests content with having laid open one kidney, he will not have liberated all the functionally capable renal substance which is possessed by the individual, all of which he assuredly needs. In such circumstances, the writer believes, the second kidney should at once be laid open if the patient's condition makes it proper to do so.

Before the operation, in cases of bilateral calculus with anuria, the surgeon can never be entirely confident which of the two organs is the more seriously damaged, unless he has had the aid of an X-ray picture taken by an expert in photography of renal calculi or unless the functional capability of each

kidney has been established by means of the ureteral catheter, before the advent of anuria, or after anuria has occurred by detecting by the same means a calculus in both ureters.

In practice we shall frequently be deprived of the aid of these procedures, for the condition is one of the most serious of surgical emergencies and when the surgeon is called in, no time can be lost in making such examinations, even if an expert X-ray photographer should be available, which is frequently not the case. The cases in which the ureteral catheter will render valuable service are also few.

In most instances we shall have to depend on the physical examination and the history of the case alone, and the chances of being misled, more particularly in cases of bilateral calculus, are considerable, because of the absence of characteristic evidence, which, were it present, would enable us to determine whether calculus exists on one or both sides, and if on both, which of the two kidneys has received the least damage.

In the unilateral cases also there will always be a certain number in which the operator must be in doubt whether the first kidney operated upon will alone be capable of sustaining life after having been freed of its obstruction. The ones in which the greatest uncertainty is likely to arise are the non-infected hydronephroses which have but a small amount of good secreting substance left in them, for we all know how long such apparently inadequate amounts of renal substance are nevertheless capable of doing enough work to keep patients alive and in reasonably good condition. With the infected renal retentions of calculus origin the operator will feel less doubt as to the functional incapability of the organ, for a well-marked infection will render unfit for service what appears to the eye to be a considerable amount of renal substance, while on the other hand what seems to be an entirely inadequate quantity will sometimes, if not infected, be capable of sustaining life. In the infected cases therefore there should be less hesitation, when the operator is in doubt, in cutting into the second kidney at once than in the non-infected ones.

A study of the cases of unilateral renal calculus with

anuria shows that in the larger number of them the organ of the opposite side is either absent or totally destroyed functionally. In the minority—but an important minority—there is more or less disease or destruction of the secreting substance of the unobstructed kidney, but enough of it is left intact to contribute importantly to the sum total of renal activity, if its function were reëstablished.

In a few instances the unobstructed kidney has been normal. There are at least four such cases authentically reported. The reflex suppression of a normal kidney has been denied by a number of observers and affirmed by others.

That the sudden obstruction of the ureter of one kidney produces total suppression of the function of its fellow organ when the latter is extensively injured or diseased, is an unquestioned fact, and though less well recognized it is also true when the disease in that kidney is but moderate or very little. That this should not happen more often in cases of calculous anuria is rather surprising when it is remembered that the same thing takes place in the remaining kidney after nephrectomy, if that kidney is more or less diseased, and that urinary suppression occurs as the result of operations upon other parts of the urinary tract or elsewhere in the body, even in some cases when the operations have been trivial in character.

Just what the number of cases may be in which the condition of the first kidney operated upon will be found to be so diseased as to make it proper to lay open the second one on the chance of freeing an additional amount of functionally active renal substance sufficient to contribute importantly to the chance of saving the patient, it is impossible to say. The point which the writer wishes to establish is merely that the probability of being able to do this by cutting into the second kidney should be judged largely by the amount and condition of the renal tissue found in the first one laid open, and whenever it is seen to be but very small in amount or if it is seriously infected and suppurating, even though it be somewhat more in actual quantity, that the surgeon should then give the patient whatever chance of benefit may be derived from

cutting into the second kidney at once, unless, of course, previous examinations with the ureteral catheter have already demonstrated the absence or total destruction of the kidney on the other side.

In conclusion the writer would also urge the performance of bilateral nephrostomy at one sitting in cases of bilateral renal calculus without anuria, as well as in those with it, except the patient's condition be such as to make the longer time required for opening the two kidneys an obviously improper danger to which to submit him.

So far as the writer is aware this procedure has been done only by himself. (The case is one of those described at the end of the communication. The patient made an uneventful recovery.) In Wagner's contribution to the Handbuch der Urologie of Frisch and Zuckerkandl, he says that the calculus should be removed from the second kidney always, then, underlining the words, he adds, *but never at one sitting.*

On what principle this advice is given and why this custom has invariably been followed with the one exception mentioned, the writer is at a loss to understand. It is not based upon actual experience of bad results obtained from having done the operations simultaneously upon the two kidneys, since the writer's case which has not been published is the only one, and as has been said, the patient made an uneventful recovery.

The only objection to the procedure that could reasonably be made is that shock might be too great if both the kidneys should be operated upon in one sitting. This objection has not been sustained in the three cases in which the writer has operated upon the two kidneys at one time for three somewhat dissimilar conditions, nor is it borne out by such experiences as we have of the bilateral simultaneously performed renal operations, such as nephropexy and decapsulation (sometimes with nephrotomy added to it.)

On the other hand in these bilateral cases without anuria there *is every reason for removing* the calculi from both kidneys at the same time, for why should suppuration—even in

cases in which there is but an insignificant amount of functionally capable renal substance present in one or another of the organs—be allowed to be perpetuated by the presence of a calculus, and why should either kidney, if functionally capable substance *is* present in it, be subjected to the destructive influence of a calculus any longer than need be. For which reasons the stones, unless of insignificant size in one of the kidneys should be removed at the same time from both organs in cases of bilateral calculus with or without anuria under the conditions named.

Appended is the report of some cases which have direct bearing upon the subject of this communication, and also a table of cases of bilateral calculus in which operations were performed—with two exceptions—upon the two kidneys at different times with an interval between the operations.

CASE I.—A multipara, aged thirty-five years. Hematuria and pyuria had been present for about three weeks before her entrance into the hospital, and were accompanied by marked vesical tenesmus and frequent micturition. There was also at that time a good deal of phosphatic sand in the urine. Up to that time she had never passed renal calculi nor had any kidney pain.

The general condition was good and there was little or no fever. The urine contained a nearly normal quantity of solids, the sediment was large. It consisted of pus, a moderate amount of blood, a good deal of thick stringy mucus, vesical epithelium, a large amount of crystals of triple phosphates and phosphatic sand. The urine was ammoniacal.

No tenderness or enlargement of either kidney. Appetite good; no constitutional disturbance.

Cystoscope showed what was believed to be a partly necrotic papilloma of the bladder, with long villi floating far out from the vesical wall.

The hematuria became much less after the patient had been in bed for a few days.

Operation.—Suprapubic cystotomy. A large mass was found occupying the interior of the bladder and attached to the lateral wall (a little external to the orifice of the right ureter) by a pedicle about as thick as the thumb.

The pedicle of the supposed tumor was divided with the writer's galvano cautery scissors, a margin of the surrounding tissue being included in so doing, and the mass was removed. On examination it proved to be the entire inner lining of the bladder which had undergone necrosis and had involved a part of the muscular structure of the organ, so that it was partly detached from the surrounding tissue and gave the impression of the pedicle of a new growth.

The bladder was drained and the incision healed slowly by granulation. The recovery was uneventful.

The patient remained well until about six months before her second entrance to the hospital. She then for the first time began to have more or less pain in both kidneys and hematuria reappeared. She also had oliguria occasionally.

For three days before entering the hospital very little urine was passed, and for the last twenty-four hours there was complete anuria. Uremic symptoms began to be manifested on the day before her admission and were progressive.

Temperature 102° to 103° F. Pulse rapid. Tongue coated. Bowels constipated. Occasional vomiting. Intellect clouded. Moderate distension of abdomen and slight spasm of the muscles of the right side. Some tenderness in both flanks. Twitching of muscles of hands and forearms. General condition critical.

Operation.—Third day of anuria, thirty-six hours after beginning of uremia. The patient was placed upon the abdomen across the inclined planes made by the Cunningham "Kidney operating table." The right kidney was first exposed in the loin; it was found to be buried in a mass of connective tissue and was universally adherent. In separating it from this mass at the upper part of the organ, a large perinephritic abscess, communicating with the interior of the pyonephrotic kidney, was opened. In the pus which escaped were several fragments of phosphatic stone. The kidney was laid open parallel with and a little posterior to its convex border.

The kidney was pyonephrotic and its secreting substance extensively destroyed. Enough of it, however, remained intact, it was thought, to be in some measure functionally capable. A perforation near the upper pole communicated with the perinephritic abscess. A large calculus lay in the pelvis and sent

branches into the dilated calyces. A part of the calculus only could be removed.

While the writer's colleague, Dr. Blake, cleansed the operative field, sutured the wound in part, and arranged drainage, the writer laid open the second kidney and removed broken bits of calculus from it. The conditions on this side were similar to those upon the other; there was, if anything, a little less secreting substance in the kidney, and the stone was smaller. The calculi occluded the outlet of the renal pelvis of each kidney. The wound and drainage were arranged as on the other side. The operations occupied twenty-five minutes altogether.

Both kidneys began to secrete within three hours after the operations, the first one operated upon, abundantly, the second one not so much. On the following morning the patient felt decidedly better and the uremic symptoms had almost entirely ceased. This improvement was maintained for twenty-four hours. Uremia was then once more noticeable, and she died on the third day.

Shock played no part in causing death. No autopsy.

CASE 2.—A man of thirty-five years of age, in good general condition, who had had for a good while more or less characteristic evidence of renal calculus on the right side, and for the past year suggestive signs of it on the left as well.

X-ray pictures showed clearly a calculus in the right kidney and gave a doubtful shadow in the left one.

Operation.—By mistake the first kidney operated upon was the one in which the doubtful shadow of the X-ray photograph had appeared. It was laid open after being exposed by the usual incision in the loin. Exploration of the interior of the kidney failed to discover a calculus. The renal and outer incisions were both closed tight by suture, without drainage. The other kidney was then laid open and a calculus about the size of a chestnut was removed from one of the calyces. The kidney was but slightly infected. The calculus had a smooth surface. A drainage tube was placed in the kidney and the renal incision was closed around it. The outer wound was closed except for a space sufficient to allow the passage of the tube. Drainage maintained for two days Wound closed in a short time. The incision on the other side healed per primam. Recovery uneventful.

CASES 3, 4, and 5.—These were all of them cases of bilateral renal infection with extensive suppuration.

The surgical intervention in the first of them was a simultaneously performed bilateral nephrostomy. Drainage of both kidneys. This patient made a good recovery without persistence of fistula.

In the other two cases unilateral nephrotomy only was done. Both patients died. Both had abscess of the other kidney. One of them would probably have lived had the second kidney been opened.

A NEW COMBINED LITHOTRITE WITH CYSTOSCOPE.

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THERE are three instruments of this kind on the market, those of Nitze, Bierhoff, and Casper, but all of them have the great disadvantage that one blade of the lithotrite is interposed between the prism and object to be seen. Moreover, owing to the mode of their mechanical construction, they are necessarily too weak to crush any stone that is not very soft and relatively quite small. These two disadvantages are so great that they render the instruments of very little practical value.

In the accompanying cuts I have shown an improved instrument so arranged that one looks directly between the jaws. It is constructed sufficiently strong to stand the strain of 175 pounds, which is amply sufficient to crush any stone except those of the hard oxalate type.

Description of the Instrument.—Figure 1 shows the complete instrument closed; (*C*) is a section looking directly between the open jaws on to the surface of the prism end of the cystoscope; (*D*) shows the jaws open (side view). The instrument (fig. 2) consists of a female blade (*A*) carrying a handle (*ab*); a male blade (*B*) carrying a screw (*g*); two attachments (*e*) for the cystoscope and (*f*) for the evacuator; a cystoscope (*C*) and a steel rod (*D*). The female blade, exclusive of the handle, is 9½ inches in length; in the straight portion it has a calibre of no. 25 French and in the curved of no. 26 French. It, as well as the other blade, is made of the very best quality of steel, highly tempered. The handle consists of two parts, a fixed (*a*) and a revolving part (*b*); (*a*) is firmly fixed to the blade, its surface is corrugated and it has two lateral flanges which prevent it turning in the hand; (*b*) the revolving cap is attached to the fixed portion by means of a ridge and a groove. It is provided

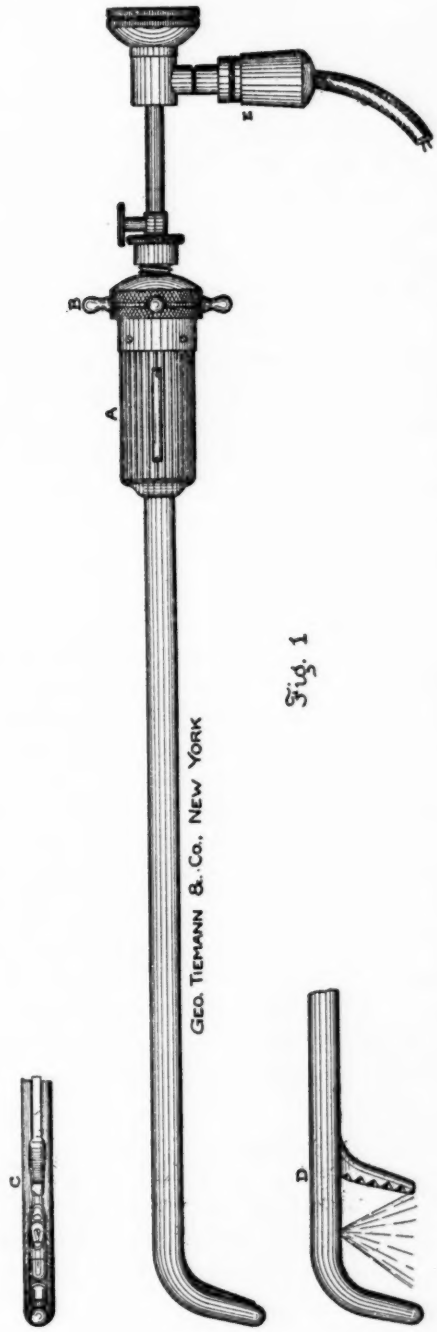


Fig. 1

with four metal pins on its surface, so as to afford a better hold. This cap is adjusted, by means of a screw thread, to the end of the male blade (*g*), a device that readily provides for the opening and closing of the jaws. The female blade and handle, except the revolving cap, are provided with an open slot, into which the ridge on the male blade fits. The distal end of the female blade is perforated so as to allow the fragments to pass through and to permit the end of the cystoscope to project when necessary. The male blade is a steel tube reinforced on the under surface by a ridge which fits into the slot of the female blade and prevents it from turning. On the proximal end of the male blade there is a cylindrical screw (*g*) on which the outer portion of the handle (the revolving cap of the female blade) turns. On the end of this screw two attachments can be fitted: One (*e*), for holding the cystoscope in place, and the other (*f*) for connecting the evacuator. The cystoscope (fig. 2, C) has a calibre of no. 15 French; it is made with a small convex prism and the lamp is turned around so as to be placed very near the prism. The attachment for the cord at the outer end is placed on the same side as the prism and lamp and not on the opposite side, as has heretofore been the custom. The electric connection is made or broken by turning the guttapercha end of the cord (fig. 1, E). The cap for holding the cystoscope is of the usual type. The attachment for the evacuating apparatus is made after the pattern of the end of the ordinary evacuating tubes, but so modified that it screws on the end of the male blade. The steel rod (fig. 2, D) is the same calibre as the cystoscope; it is one-half an inch longer and has a small flat handle on the proximal end. This is intended to pass through the instrument and clear it of any fragments which might have become lodged in the tubal portion. The instrument with the evacuator attached is shown in fig. 3. This principle has been used for a number of years in the Chismore instrument. It is not, therefore, illustrated as anything new, but simply to show its adaptation to my instrument.

Mode of Using.—The bladder is thoroughly irrigated until the returning fluid is entirely clear, 150 cc. of clear sterile water being finally left in. The instrument, adjusted as shown in fig. 1, is then introduced; the jaws are opened by

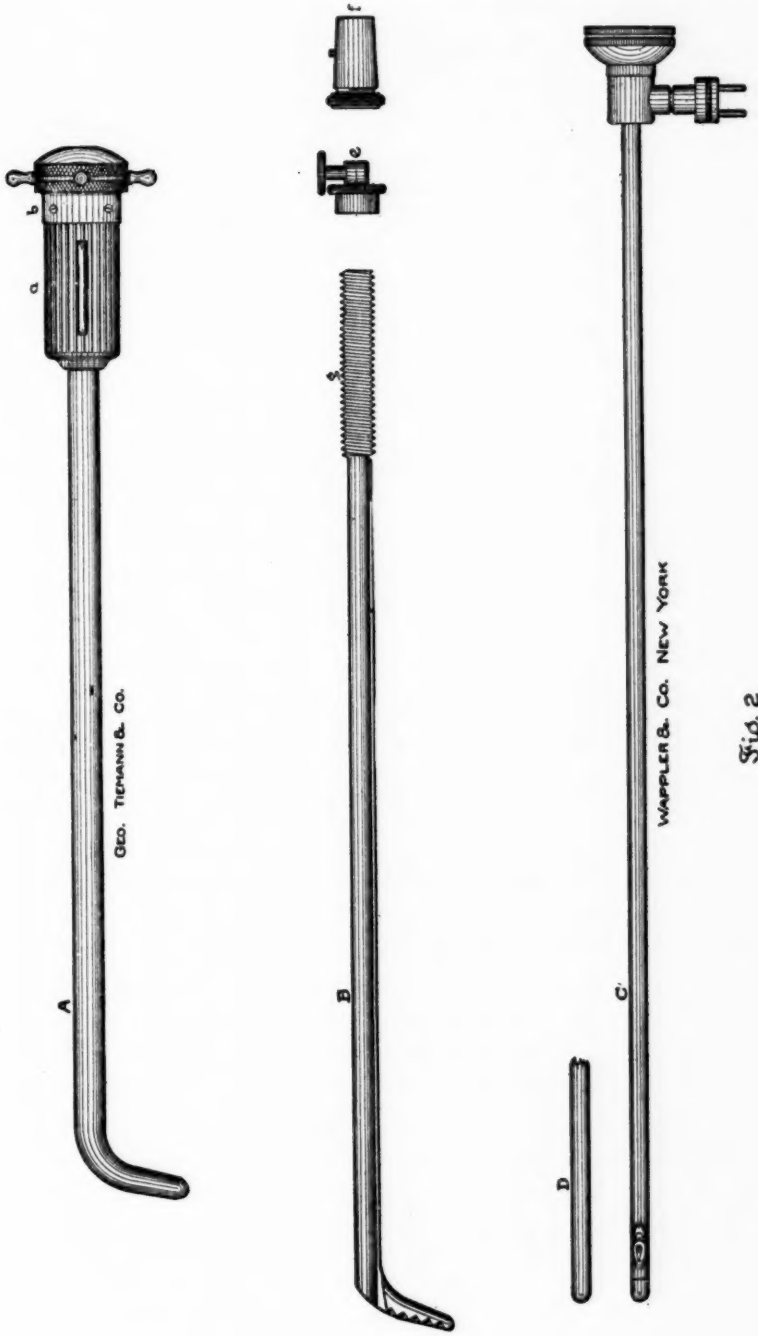


Fig. 2

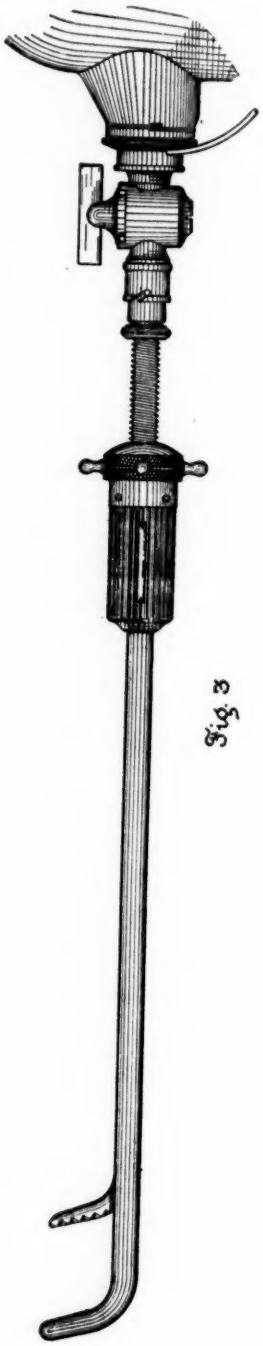


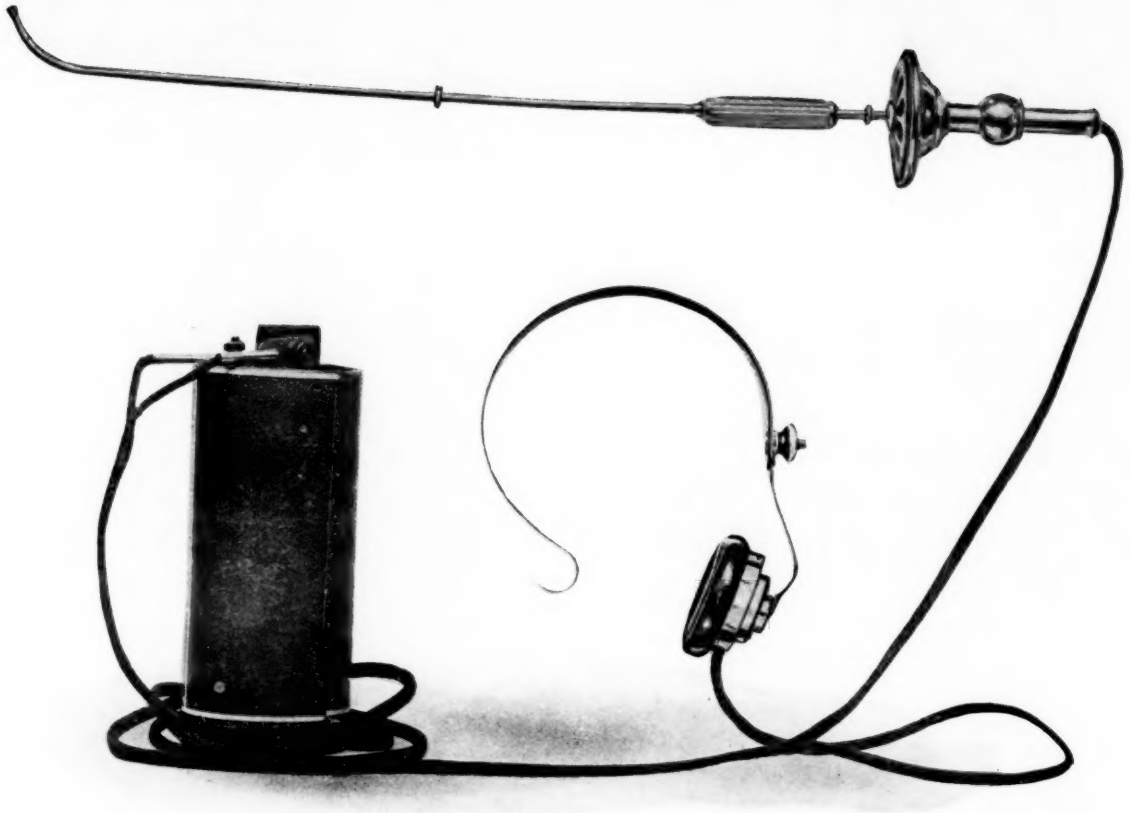
Fig. 3

turning the screw from right to left; the cystoscope is adjusted in such a way that the line of vision is between the open blades. The stone is then located and the male blade, which can be seen, is placed squarely in front of it, and the jaws are closed by turning the screw. Before the jaws are entirely closed the cystoscope is turned so that the prism surface will be protected. In some instances it is better to pull the cystoscope well back into the male blade so that it cannot be injured by the stone. After the primary crushing the larger fragments are sought for and broken. If during the crushing some fragments are forced into the tubal portion of the male or female blade, the cystoscope is removed and the steel rod passed through so as to clear the canal; after which the cystoscope is reintroduced. When the crushing is finished the cystoscope is removed and the evacuator attached (fig. 3). After this, the lithotrite is turned around so that the convex surface rests on the floor of the bladder and the beak projects upward into the cavity. The jaws are separated from ¾ to 1 inch, and the fragments are washed out in the usual manner. If there is any doubt as to the completeness of the operation the bladder is again filled with water and the cystoscope reintroduced. In filling the bladder it is better to raise the outer end of the instrument so that the water will not run out; if it, however, tends to do so, the end of the finger may be held over the opening. As the cystoscope is introduced, if there is much vesical contraction some fluid will escape, but the amount will be insignificant and the deficiency can be easily provided for beforehand by injecting a little more than is necessary for proper distention. If the operation is done under cocaine and the vesical contraction is violent some leaking will occur during the whole operation, but if the bladder is quiet the amount is reduced to a minimum and is not troublesome.

The object of this instrument is not to supplant suprapubic section or the use of the ordinary lithotrite, except in certain cases. It is intended to be used not for large or hard stones, but for small ones of the soft variety.

NOTE.—After having completed my instrument, I found in an old catalogue a cut of Casper's lithotrite, which formed a part of his operating set. It was impossible to get a very correct idea, but the instrument appeared to be constructed out of two tubes, one passing into the other and each carrying jaws on their distal ends. The cystoscope, which is straight, passes entirely through so that one blade is between the prism and the object. I have tried to find a better illustration and have applied to two of the largest instrument makers in New York, but they could tell me nothing about it.

I beg to thank Mr. R. Wappler for valuable suggestions in the adaptation of the cystoscope to the instrument and Mr. L. G. Pfarre for suggestions in the construction of the lithotrite.



Jacobson's Telephonic Searcher.

A TELEPHONIC SEARCHER FOR USE IN THE BLADDER.

BY ARTHUR C. JACOBSON, M.D.,

OF BROOKLYN.

The accompanying illustration shows a Thompson searcher attached to the front of a telephone transmitter through the medium of a plug joint. The transmission to the ear of sounds produced by contact of the end of the searcher with stones or other objects is actually microphonic. So delicate is this lithophone that the character of varying surfaces may be nicely differentiated by lightly rubbing the end of the searcher over them. The tapping of hard objects produces sounds so loud as to be almost unpleasant to the ear.

The searcher is introduced in the usual way, after which the transmitter is connected with it.

No stone, however small, will fail of detection if touched by the searcher, however lightly. Much may also be inferred regarding the constitution of a stone from its smoothness or roughness, hardness or softness, as determined by the sounds elicited.

In the diagnosis of stone probably no one will take issue with Agnew's dictum regarding the greater trustworthiness of the sense of hearing as compared with the sense of touch.

One dry cell operates the apparatus.

The midget receiver and watch-case transmitter made by the Schmidt-Wilckes Electric Company, of New York City, have been employed because of their small size.

NOTE.—This apparatus may, if desired, be used in conjunction with the lithotrite.

"GAUZE-ETHER," OR A MODIFIED DROP METHOD, WITH ITS EFFECT ON ACETONURIA.

BY W. E. LADD, M.D., AND GEO. OSGOOD, M.D.,

OF BOSTON, MASS.,

House Surgeons in the Boston City Hospital.

OUR intention in this paper is to describe in some detail the method of etherization introduced by us into the Boston City Hospital, to point out its advantages, and to consider especially its effect on post-operative acetonuria.

The method of etherization employed by us is as follows: A square pad of gauze twelve layers thick, and sufficiently large to cover the patient's mouth and nose, extending well down over his cheeks, is laid directly on the patient's face. Ether is then dropped on this gauze by means of a drop bottle consisting simply of an ordinary bottle with a small wick inserted through a slit in the cork. Ether having been dropped slowly for about one minute on this pad of gauze described above, another similar pad is laid on the first, and the rapidity of the drops is increased and continued until the patient becomes thoroughly anæsthetized. It is very important that the ether should be gradually administered in this way, and not poured on in large quantities at a time, which not only hampers the etherizer in getting the patient narcotized, but also is inconvenient on account of the possibility of causing ether burns on the face, respiratory spasm, or at least coughing. When, however, the ether is administered as directed, the strength of the vapor is so gradually increased that the respiratory tract becomes accustomed to it without any sense of suffocation on the part of the patient. With this lack of sense of suffocation, and no incentive to struggle, we find that the stage of excitement referred to in all text-books on anæsthesia, and seen usually with other methods, is as a rule not recognizable; and that there is no necessity of having an assistant to restrain the patient while he is taking the ether.

The question is now naturally asked, "How long does it take to produce complete surgical anæsthesia by this method?" In answer we would say that the average time is about five minutes. In our series of 102 cases, the average time was four minutes and twenty-nine seconds. The shortest time was one minute and a half, and the longest ten minutes.

Next, how much ether does it require? Of course, the amount of ether necessary to produce and maintain anæsthesia, with this as with other methods, varies according to the patient. In our series the average amount required to produce and maintain anæsthesia was seven ounces per hour. In one case on which a gastro-enterostomy and cholecystotomy was done, the duration of the operation being one hour, only one and one-half ounces of ether were used during the whole time. The above facts show conclusively that in this way complete narcosis can be quickly produced and maintained with a small amount of ether.

Now, let us consider the objections which have been raised to this method:

First, it has been suggested that the ether being dropped on gauze placed so close to the patient's face must chill the respiratory tract, and be a causative factor in producing bronchitis or pneumonia. At first thought it seems as though this idea might be well founded and true. But if anybody using this method properly, by which we mean using it as a drop method, and not pouring on large quantities of ether at a time, will take the trouble to place his finger between the patient's mouth and the gauze, he will find that it is not only not cold, but that it is far warmer than when placed inside any metal cone.

This observation led us to believe that for one reason at least, bronchitis was less apt to occur, and on investigating the subject we found this was in point of fact true. Dr. Ladd made three visits at different times to every patient on the service on which he worked. He found on the three visits, two cases with bronchitis, one of which had it before etherization, and with whom it persisted afterward and was of considerable

severity. The other was very slight, and cleared up in two or three days. Dr. Osgood, on the service on which he worked, found one case of ether pneumonia which had not been etherized by him, or by the gauze method, but by a house-officer of considerable experience in anæsthesia and with a Blake cone.

Now, with regard to etherizing alcoholics by this method. We have been fortunate in having some patients who had to be anæsthetized twice. The first time with the cone they were etherized with great difficulty, whereas on the second, with the gauze they were narcotized far more easily. This, with the fact that the alcoholic patients as a rule cause us less difficulty with the gauze than with the cone, leads us to the belief that the gauze method is particularly suited to that type of patient.

The other objections which have been raised are the likelihood of ether burns on the face, or ether conjunctivitis. To this we consider it sufficient to state that no patient etherized by the writers has ever had either of these sequelæ.

If we consider the ideal etherization that in which there is the greatest amount of fresh air with the minimum volume per cent. of ether necessary to produce anæsthesia, we must of necessity regard any closed, or semi-closed method as directly antagonistic to the first principles of etherization, for thus we do our utmost to exclude oxygen.

Having seen that the objections offered against the method do not exist when it is intelligently applied, let us consider whether it has advantages sufficient to recommend its more general adoption. First and foremost we believe that the comfort and the feelings of the patient should always be considered. We have been fortunate enough to have had several patients who had previously been etherized by the cone or other methods. Every one of them expressed a preference for the gauze method.

Next, with this method the usual absence of the stage of excitement and struggling must be beneficial to the patient's general welfare. The time required to produce anæsthesia in this way being less than by any other method of etherization with the exception of the gas-ether sequence, is of course of

value for the convenience of the operator and also beneficial for the patient.

The difference in the patient's recovery is very marked. So rapidly do they come out of ether that by the time the dressing is applied and the patient taken to the recovery ward, he is frequently able to assist himself from the truck to the bed, and even to answer questions rationally before being removed from the operating table.

With regard to vomiting: We were unfortunately not able to observe all the cases, but 52 out of 77 patients whom we did see, did not vomit at all, 19 vomited once or twice, and 6 presented the usual distressing degree of vomiting following etherization in other ways.

In other words, 67½ per cent. of the patients did not vomit at all, and of the 32½ per cent. who did, only 8 per cent. exhibited marked and distressing vomiting.

We have also compared the effect of the gauze method with that of the cone in producing post-operative acetonuria, making observations in 222 cases in which there was no acetone before operation.

It has been generally considered that, barring organic disease or idiosyncrasy of the patient, ether alone does not produce any lasting unfavorable effect; Grevin, however, has shown that there is enough disturbance in metabolism in almost every case of anæsthesia to cause a marked acetone reaction in the urine.

Of the several tests for acetone, the following proved to be the most practical and satisfactory:

To one-quarter test tube of urine add a few drops of a saturated solution of sodium nitro-prussiate. Then add a few drops of glacial acetic acid and shake thoroughly. Now pour down the side of the tube 2 c.c. of ammonium hydrate. If acetone be present, there will appear at the line of contact, a crimson red zone which gradually changes to deeper red, and if much acetone be present, becomes diffused throughout the fluid, being at first more intense and fading later. Sometimes the colored zone does not appear for several minutes.

This test detects 8 mll. of acetone in the twenty-four hour amount of urine.

With this test we first examined the urines of 120 patients etherized with the cone or semi-open method, following a few of them as long as four days after the operation. All these patients were etherized with the Blake cone, no gas being used and the duration of the etherization varying from fifteen minutes to two hours and a half.

Of these 120 cases, 106 showed varying amounts of acetone, the intensity of the reaction in many cases being in direct proportion to the duration of the etherization. Out of the 14 cases not giving the reaction for acetone, there were but 5 where the administration of the anæsthetic exceeded twenty minutes, and only one where etherization was continued for one hour.

In every case here recorded the acetonuria developed before the eighteenth hour after operation. Of 10 cases where the first urine was voided within six hours after etherization, 9 showed acetone. The other case had acetone in the urine at the end of eighteen hours.

As to the time of the disappearance of acetone from the urine we can only say that we have found it in a number of cases up to the fifth day.

That acetone may be due to a restricted diet before or after operation is possible, and with this idea in view we examined the urine of four patients etherized on a full stomach with the cone. All 4 cases showed acetonuria. This, together with the definite relation between the length of etherization and the intensity of the reaction, shows that the sole cause of acetone in these post-operative urines, cannot be the restricted diet before and after operation,—furthermore, three of these patients had compound fractures and were on house diet twenty-four hours after operation, although acetone continued in the urine to the fourth and fifth day.

In these 120 post-operative urines examined, 106, or 88½ per cent. showed acetone.

These results, corresponding very closely with those of

other observers, would lead one to suppose that acetone appears in the urine after ether narcosis in about 90 per cent. of the cases. Now although acetone does occur in this large majority of cases, it is only in a very few that it is accompanied by the grave symptoms of acid intoxication, which are characterized by an odor of acetone in the breath, nausea, followed by vomiting, coming on 12 to 36 hours after operation. The vomiting increases, the pulse becomes very rapid and feeble, respirations increase and grow shallow, the patient may become delirious or comatose, and finally die at the end of twelve to forty-eight hours.

Now, though every case having acetone in the urine does not present serious symptoms, neither does every case of diabetes present serious symptoms. Still, we well know that acetone in quantities sufficiently large to be detected by any of the ordinary tests is a pathological constituent of the urine and indicates some metabolic change which may be more or less serious, occasionally serious enough to cause death and to show fatty degeneration of the liver and kidney post mortem, as has been demonstrated by Bevan, but more frequently this is not severe enough to produce any easily noticeable symptoms.

Whether or not acetone is the cause of the disease which presents the above symptoms is not yet settled, but we do know that the patients showing the symptoms have invariably had acetone in the urine in the cases in which it has been tested, we therefore believe that it should be regarded as a danger signal following anæsthesia and that every effort should be made to avoid its occurrence or to diminish its quantity in the urine.

The question which naturally arises is "How can this be done?" We have already stated that 88½ per cent. of the patients etherized by the semi-open or cone method showed acetone in the urine, while the employment of the simpler, cleaner, and more rational method of anæsthesia which we have described, reduced the percentage of post-operative acetonuria from 88½ to 26 per cent.

In conclusion, we may summarize the advantages that we claim for the gauze method of etherization, thus—

1. It is less disagreeable to the patient.

2. Post-operative vomiting is reduced from nearly 100 to 32½ per cent.

3. Quicker recovery of consciousness.

4. Reduction of post-operative acetonuria from 88½ to 26 per cent.

In closing, we wish to express our thanks to Drs. Burrell, Watson, and Blake, through whose courtesy we have had the opportunity to carry out this work, and especially to thank the latter, at whose suggestion the work on acetone was undertaken, for his valuable advice and encouragement.

TRANSACTIONS

OF THE

NEW YORK SURGICAL SOCIETY.

Stated Meeting, April 24, 1907.

The President, Dr. George Woolsey, in the Chair.

SARCOMA OF THE HUMERUS.

Dr. Howard Lilienthal presented a man about 30 years old, who, six months ago, after the healing of a fracture of the right humerus, noted peculiar sensations and pain in the callus. The pain finally became so marked that he visited the Mt. Sinai Dispensary, where he was seen by Dr. Walter M. Brickner, who, partly on account of the crackling sensation that could be elicited, became suspicious that the condition was malignant and had an X-ray photograph taken. This corroborated his suspicions, and the patient was admitted to the hospital about two months ago.

Upon exposing the humerus and opening it, the medullary canal was found to be filled with a soft, pultaceous material, which was removed and submitted to the pathologist, who pronounced it small, round-celled sarcoma. As the patient absolutely declined amputation, the diseased bone was removed as completely as possible, comprising a section about seven inches long. Even above this, and extending up into the shoulder, the bone was so extremely thin and brittle that it could be broken between the fingers.

In order to give the patient a fairly useful arm, at least temporarily, a prosthesis was determined on. This was accomplished by the insertion of an aluminum intra-medullary splint, as first suggested by Dr. Charles A. Elsberg, which was introduced into the medullary canal of the lower and upper fragments; is fitted snugly below, but not so well above, on account of the thinness of the bone. The wound was closed with drainage, and

the patient made a rapid recovery. Since then he had been treated by injections of Coley's fluid, and he now wears an apparatus, which, while not entirely satisfactory, is fairly so, and enables him to use the affected arm.

The future of this case, Dr. Lilienthal said, presented an interesting problem. If he remained free from a recurrence, which was scarcely to be expected, the aluminum splint would have to be replaced by some other material, as the aluminum would in the course of time be dissolved by the alkalinity of the blood, and become absorbed.

Dr. Frank W. Murray asked whether the absorption of the aluminum might not perhaps be prevented by gold-plating the aluminum rod? As to a future operation in this case he would suggest reopening the upper part of the wound and fitting the upper end of the aluminum rod more firmly into the canal of the upper fragment of the humerus.

Dr. Lilienthal said he believed aluminum could not be gold-plated. Instead of aluminum, a splint of silver or of silver plated with gold might be tried, although it was questionable whether such a splint would remain in situ.

Dr. Charles A. Elsberg said that when he suggested the use of the aluminum splint, he did not have in mind cases like the one shown by Dr. Lilienthal. On the contrary, the absorbability of the aluminum splint in the cases in which he desired to use it was of distinct advantage, as it would disappear after it had served its purpose. It was intended simply to hold the divided fragments of bone in place temporarily, especially in cases where there was a slight gap between them. In a case of advanced tuberculosis of the knee joint which recently came under his observation, it was necessary to remove a considerable section of bone, leaving a gap of about two inches. An aluminum cylinder was then introduced into this gap, forcing it into the tibia below and the femur above. This wound was still unhealed, owing to the prolonged drainage that was necessary, but fully two-thirds of the gap between the femur and tibia had already been covered by a new growth of bone.

EXTRA-DURAL HÆMORRHAGE.

Dr. Charles Elsberg presented a young man of 20 who was admitted to Mt. Sinai Hospital on March 19, 1907, with the

following history: Two days before he had spent the day drinking with some friends, and in a fight he was said to have been struck on the left side of the head. He returned home in the evening in a dazed condition, but was able to go to bed without assistance. In the morning he got up and sat around the house, but toward evening he became more drowsy. At nine o'clock that evening he was brought to the hospital by his brother. He was able to walk, the distance being about ten blocks. Upon admission, he was in a semi-conscious condition; when aroused, he was able to answer questions. His pulse ranged between 50 and 60 per minute; respirations, 20; the pupils reacted to light, but the left was slightly larger than the right. There was distinct weaknesss, almost amounting to palsy, of the entire right side of the body. The reflexes on that side were exaggerated. Over the left temporal region there were numerous contusions, and cracked-pot sound could be elicited on percussion over the lower part of the temporal region. There was slight congestion of the retinal vessels. It was determined to delay operative interference for a few hours, in the meantime having the patient carefully watched.

The following morning his condition was about the same, excepting that the pulse and respirations had fallen slightly, and drowsiness was perhaps more marked. Further delay was considered inadvisable. Under anæsthesia, Dr. Elsberg made the usual incision in the left temporal region. When the bone was exposed, a fracture was seen running forward and downward. Part of the bone in this region was removed with gouges and rongeur. As soon as the dura was exposed, a large blood-clot was expelled under considerable pressure. The opening in the skull was then rapidly enlarged, and a very large amount of clotted blood was removed with the fingers and by irrigation. The anterior branch of the middle meningeal artery was then found to be bleeding, and it was secured by ligatures. The original blood clot extended from the frontal to the occipital region, and from the median line to the base of the brain, and in the temporal region the dura was separated fully an inch and a half from the inner surface of the bone. Within a few minutes after all the clots had been washed away, the dura resumed its natural position. The skin flap was then sewn back into place, a small drain being inserted to the region of the ligated artery.

The patient's convalescence was rapid and uneventful. By the evening of the day of operation the right-sided paralysis had entirely disappeared, and the boy was partly conscious. The pulse and respirations, however, remained slow for twenty-four hours longer. The respirations gradually rose to normal, and after that the pulse rate. The wound healed by primary union, and the boy was up eight days after the operation. Blood-pressure observations were made before and during the operation, and they showed in a characteristic way that there was no change when the dura remained unopened. The large area of dura compressed by the clot without marked pupillary changes was also of interest.

Dr. Benjamin T. Tilton said that in the cases of extra-dural hæmorrhage he had seen there was no free hæmorrhage after removal of the clot, and he had seldom found it necessary to ligate the artery.

ABSCESS OF THE LUNG.

Dr. Frank W. Murray presented a boy 16 years of age, who was admitted on January 12 to the medical service of the New York Hospital. Some six weeks previous he had a severe attack of tonsillitis which lasted a week. Since then he has complained of headache and cough with mucoid expectoration. Two days before admission he was suddenly taken with severe pain below the right costal margin. The pain was increased by coughing and on deep inspiration. Examination of the chest on admission revealed dulness on percussion and bronchial breathing accompanied by many large râles over the lower lobe of the right lung. Temperature 101.6°, pulse 114. During the following week the area of dulness extended upward to the angle of the scapula and outward towards the axilla, and as fluid was suspected, the pleura was aspirated in two places, but with negative results. The temperature still continued elevated, averaging about 102° every afternoon, the pulse averaged 116, and the general condition did not improve. On January 25 there was noted an area about six inches from the spine and corresponding to the lower third of the scapula and extending an inch below the angle where percussion was hyper-resonant, the breathing caverno-amphoric, fremitus, increased whispered pectoriloquy present with an occasional râle. Dulness on percussion now

extended into the axilla as far forward as the anterior axillary line. The patient was much weaker, perspired profusely at night, and was steadily losing ground. The evening temperature at this time averaged about 103.5° and the pulse about 130, respiration up to 40. During the following four days the evening temperature was over 104° and the pulse averaged about 150. Examination of sputum revealed diplococci, staphylococci and streptococci; no tubercle bacilli found. On February 1 a needle inserted into the right chest at the angle of the scapula withdrew two ounces of pus. No improvement followed the aspiration except some lowering of temperature, but the local symptoms remained the same. On February 4, the temperature having risen to 105° and the pulse to 168, the patient was transferred to the surgical service of the hospital for operation.

Operation.—Light ether anæsthesia, patient in semiprone position, his right arm hanging over the edge of the table. The needle, inserted in the ninth interspace behind, withdrew pure blood. Inserting the needle in seventh right intercostal space at about the location of the spine of the scapula, and pushing the needle upward and forward for about an inch and a half, pus was withdrawn. An incision at this point was made down to the seventh rib, one and a half inches of which was removed, and on opening the pleura, a cavity about three-quarters of an inch in diameter and walled off by adhesions, was found. The needle was then inserted upward and forward through the floor of the cavity and pus again withdrawn. On palpating the floor of this cavity with the index finger, the tissues were found to be very soft and friable, and on pressure the finger broke through into an abscess cavity about the size of a hen's egg. Then followed an escape of gas, together with a discharge of light-colored, odorless, viscid pus. After carefully cleansing the abscess cavity, it was found to be in the lung tissue proper, and it was not an interlobular empyema. A drainage tube was inserted into the pus cavity and the wound partially sutured and covered with a large sterile gauze dressing. The operation was followed by rapid improvement, and on the following day the temperature had dropped to 99° and the pulse to 104, with a corresponding improvement in the boy's general condition. The discharge from the wound was profuse for several days, requiring frequent change of dressings. But it steadily decreased, and on February

16 the tube was removed. The patient was discharged early in March with a small granulating area, which has since healed.

Bacteriological examination of the pus removed at operation showed streptococci, apparently in pure culture.

The etiology of the abscess is somewhat uncertain, but while on the medical side of the hospital, the patient was treated for pneumonia, it should be remarked that during the entire course of the disease there was no cough with the characteristic pneumonia expectoration. The pus which was removed on February 1 by aspiration was thought to have come from a localized empyema, possibly from a lung abscess. Whether there was any connection between the lung abscess and the attack of tonsillitis in the previous December, it is difficult to say, but as the bacteriological examination showed pure streptococcus infection, and as the tonsillitis was presumably a streptococcic sore throat, the connection is somewhat suggestive. The speaker's experience with abscess of the lung was very limited, as he had only operated on two cases.

The patient is now entirely well, has good color, is able to work, and has no cough or expectoration. Over the lower lobe of the right lung there is still some dulness on percussion and a few râles are to be heard. The wound has entirely healed and the use of the shoulder and scapula muscles is unimpaired. He has gained fifty pounds in weight since operation and now weighs 115 pounds.

THE OPERATIVE TREATMENT OF ACUTE ABSCESS OF THE LUNG.

Dr. Benjamin T. Tilton read a paper with the above title, for which see page 243.

Dr. Murray said that while he agreed essentially with Dr. Tilton concerning the treatment of acute abscess of the lung, there was one point on which he slightly differed, and that is whether or not aspiration of the lungs should be resorted to in cases where there are no adhesions presenting for fear of contaminating the pleura. In his opinion the danger of contamination was more apparent than real, and in any given case where no adhesions were present, the question of immediate evacuation of the abscess depended on the patient's general condition. If it was possible to wait with safety for twenty-four or thirty-six hours to allow

adhesions to form, such a course would be advisable. In case, however, the patient was very septic and in a critical condition, immediate evacuation of the pus is indicated, and the danger of contamination of the pleura can be materially lessened by gauze packing around the line of incision. In the opinion of the speaker success in operation would depend to a great extent on the establishment of a diagnosis at the earliest possible moment. In order to establish the diagnosis definitely, aspiration is necessary, and in resorting to that the physician is not always certain whether adhesions are present or not. If the danger of contaminating the pleura were as great as expressed by the reader of the paper, it would be reasonable to suppose that septic infection would follow more frequently than it does in the hands of our medical confréres, who resort so often to it.

Dr. Howard Lilienthal said that if aspiration was done in a case of abscess of the lung in which there were no adhesions, the withdrawal of the infected needle would in all probability contaminate the pleura, and an empyema would result, usually with fatal consequences. The speaker said he had operated on two cases of abscess of the lung. In one the abscess was found at the time of operating and in the other at the autopsy. Both cases died of pneumothorax.

Dr. Lilienthal said that after listening to Dr. Tilton's paper, he felt more inclined to operate on these cases than heretofore, and in any suspected case he would be willing to try Dr. Tilton's procedure of incising the pleura and resecting the rib, and then going in through a second opening at the site of the adhesions, if any were found. In the case shown by Dr. Murray, such adhesions were evidently present, and Dr. Murray was fortunate in entering the lung through the right spot and effecting such a brilliant cure. The speaker said he had on two occasions attempted to suture the two layers of pleura together, but the sutures would not hold.

As to the danger of creating a pneumothorax in cases where there was not an inflammatory condition of the lung, Dr. Lilienthal said he did not think it was as great as had been feared. He recalled a case where some years ago he removed a sarcomatous growth involving two ribs, which were excised, together with a large section of pleura. Some pneumothorax resulted, but the patient made an excellent recovery, and was still in good health.

DR. JOHN B. WALKER said he had seen two cases of abscess of the lung. In one case, where it followed pneumonia, he excised a portion of the rib, exposing an area of adherent pleura through which the abscess was opened. Death occurred in about two weeks. In the other case, where the abscess of the lung was not interfered with, the patient recovered.

DR. L. W. HOTCHKISS referred to one case of direct operation for abscess of the lung which had been recognized beforehand. The patient was a child, and the abscess was situated in the upper portion of the chest and was easily reached. It was found to be gangrenous, and the child died in the course of a few days.

DR. LILIENTHAL asked Dr. Tilton what his ideas were in regard to draining a tuberculous cavity of the lung, and whether the tactics he had outlined, either the same or properly modified, could be followed there?

DR. GEORGE WOOLSEY said that while the danger of infecting the pleura from the introduction of a needle into a lung abscess was evidently a real one, it was not absolutely fatal in the speaker's experience. He recalled two cases of abscess of the lung, both seen within the past three years, and both fatal. One of them was diagnosed as aspiration pneumonia, and was associated with a very powerful odor. There was some improvement after operation, but the patient succumbed in the course of two or three weeks. In both of these cases there were adhesions, so that the pleural cavity was not opened.

DR. TILTON, in closing, said that he had operated on five cases of abscess of the lung, with one death, and thought that these good results were due to early operation. The mortality of abscess of the lung in hospitals is very high, and the most plausible explanation for this is that most of the cases are referred to the surgeon in a bad condition; otherwise, the operative statistics would doubtless be more satisfactory. In almost all of the gangrenous cases, a fatal outcome is to be expected. The speaker said that under certain conditions he saw no objection to an exploratory operation before the diagnosis was absolutely made. For example, in a case of pneumonia with delayed resolution where we failed to find pus by the ordinary methods, he saw no objection to resecting a rib over the probable site, which could then be located definitely by the evidence of adhesions and thick-

ened pleura. Through the adherent pleura multiple punctures could be safely made in the expectation of finding pus. When adhesions were present, it made no difference how many punctures were made.

Dr. Tilton said he had had no personal experience in draining tubercular cavities. The results of others in that direction had been very unsatisfactory. Most of those cavities were in the upper lobe, and the results of opening them from the outside were not at all good. In dealing with simple abscesses of the lung, the prognosis after early operation was very good, as was shown by Dr. Murray's case. Medical men, as a rule, preferred to wait until the pus broke through into a bronchus, but personally, the speaker said, he thought it advantageous to operate early, even before the diagnosis was positive.

FRACTURE OF THE FIFTH METATARSAL BONE.

Dr. George Woolsey reported this case, with X-ray findings. The patient was a woman who sustained the injury while the foot was strongly supinated. Examination showed some swelling and tenderness on the outer side of the foot between the fifth metatarsal bone and the cuboid. No displacement could be made out. An X-ray picture was then taken, which showed a fracture of the fifth metatarsal, with avulsion of its proximal end. The foot was put up in plaster, and the result, after five weeks, was very good.

TRANSACTIONS

OF THE

PHILADELPHIA ACADEMY OF SURGERY.

Stated meeting held May 6, 1907.

The President, JOHN B. ROBERTS, M.D., in the chair.

THE ANNUAL ADDRESS IN SURGERY.

DR. EDWARD MARTIN delivered the annual address for 1907.

SURGERY OF THE VASCULAR SYSTEM.

A symposium on the above subject was conducted, consisting of the following papers:

I. Ligation of the Ductus Arteriosus, by Dr. John C. Munro, of Boston; II. Arteriotomy for Embolism and Thrombosis, by Dr. Francis T. Stewart; III. Technique of Blood Vessel Suture, with Demonstration of Specimens, by Dr. J. Edwin Sweet; IV. Endo-Aneurismorrhaphy (Matas), with Report of Two Cases, by Dr. Charles H. Frazier; and V. Endo-Aneurismorrhaphy (Matas) with Report of Two Cases, by Dr. John H. Gibbon.

For these papers, see pages 335–366.

DR. GEORGE E. BREWER, of New York, said that for years he had been interested in this phase of surgery, particularly the Matas operation, and has long wished to hear the results of that procedure as detailed in the instances just reported. He has never carried out the procedure himself as none of the cases in which he expected to employ it proved suitable. He has, however, met with a case similar to one of those described by Dr. Frazier. It was one of aneurism of the first part of the femoral artery and the vessel above and below was ligated with the expectation of later excising the sac. Ten days later he began excision but found excessive hemorrhage, due, as in Dr. Frazier's case, to

two or three branches in the wall of the sac. Hemorrhage was with difficulty controlled. Such vessels are apt to be found in aneurismal sacs in this location. Dr. Munro's suggestion regarding the ligation of the ductus is to be thought of in suitable cases. If the diagnosis can be made the treatment is rational as the hopelessness of these cases is well known.

Dr. Brewer's own work has been experimental, based on efforts to close accidental wounds of arteries. The first accident was the wounding of an external iliac during a hernia operation, the suture being introduced from below upward instead of downward. Bleeding was profuse and it was found that a Hagedorn needle had passed through the vessel. Two attempts were made to suture the artery, in which the wound was one-fourth inch long. Tension was high and the sutures tore out each of two times they were inserted. The vessel was then ligated. Fortunately there was a free collateral circulation which maintained such satisfactory conditions that the patient never knew he had more than a hernia operation.

The second case was one of cancer of the breast in which a house surgeon who was operating plunged a knife into the axillary artery. The vessel was sutured and apparently no thrombus formed. Several mattress sutures of fine silk were inserted with a round needle, the walls of the vessel being so thick that the intima was probably not wounded. Six weeks later the clinical result was good. This is the only artery he has ever successfully sutured. These accidents led to the experimental work reported a few years ago, in which he used for wrapping the vessels, an elastic plaster made up of a strip of very thin gum, coated with an adhesive material like that used in the zinc oxide plaster. Experiments were made on a large number of animals and some of the results were good. He regards the method as worthy of trial in accidental wounds of the arteries.

Dr. John B. Murphy, of Chicago, described a case of double embolism involving the right femoral below Poupart's ligament and the left common iliac, the case being one of sepsis and malignant endocarditis following extraction of a tooth. Removal of the obstruction in the legs was thought of but embolism of the brain caused death before the operation was undertaken.

The work of Dr. Sweet is appalling from the standpoint of the time and labor necessary. Dr. Murphy is pleased with the results obtained, not only in the technical work but also in the train of thinking in respect to thrombosis in arteries and veins. From this one comes finally to the practical results of arterial work shown in the cases of Frazier and Gibbon; the work from 1889 on by Matas and others is showing results. In analyzing the work done in the suture of arteries it may be reduced to three essential methods: first, end-to-end suture; second, end-to-end implantation; third, suture by mechanical support. The third, promulgated by Abbe, was not a bad idea.

For practical suturing of vessels two things are essential; there must be no immediate hemorrhage and no immediate thrombosis. Gangrene results from immediate primary ischemia. If ischemia come on gradually there is no thrombosis, this being shown clearly by specimens in the British museum. If therefore we can devise an operation that will tide over a few days, we will succeed. In an aneurism where it is impossible to employ the Matas operation if we can produce a gradually occluding endarteritis in the proximal vessel the lesion will be cured. Most of the work upon arteries previously reported was too coarse. The greatest element in the production of endarteritis is trauma and not infection; where the artery is pinched is the point of greatest danger. Carrel's great care in handling and suturing the vessels is his dominant point, and this adds more to his success than does any other feature of his work.

Dr. J. C. Hubbard, of Boston, said that his experience in arterial surgery had been obtained by doing an arterial venous anastomosis in two cases for reversal of the circulation.

The first case, already published in the Annals of Surgery for October, 1906, was that of a man of 80 years with senile gangrene of a portion of the right foot. Physical examination showed him to be a decidedly senile old man with atheromatous arteries and a systolic heart murmur. No pulsation could be felt in the right dorsalis pedis artery. In May, 1906, he was operated upon. The femoral artery and vein were isolated in Scarpa's triangle below the origin of the profunda and divided between Crile's clamps or elastic ligatures. The upper end of the artery was then invaginated into the lower end of the vein and the distal end of the artery into the proximal end of the vein.

A complete reversal of the circulation was thus established. The technique of the invagination was as follows: Three double headed sutures were passed equally distant through the entire wall of the artery from inside out. The needles were then passed into the lumen of the vein about a quarter of an inch and at this point through its wall. When these sutures were drawn tight the artery was drawn into the vein. Reënforcing sutures including only the outer portion of the arterial wall were then placed here and there to catch the edge of the overlying vein to the artery. Number 1 Pagenstecker thread was used for all these sutures. When the controlling clamps were removed there was no leaking at either suture line and weak pulsations could be felt in the vein for a short distance below the anastomosis. There was absolutely no shock shown by the patient and recovery from the operation was satisfactory in spite of the fact that the senile condition of the patient made it difficult to keep him in bed or a dressing on the wound. After the operation the appearance of the leg did not change. There was no œdema, dilatation of the veins or cyanosis. The gangrene which existed before the operation spread a little and then a line of demarkation formed. When the foot was later amputated at the point of election on the tibia both tibial arteries contained arterial blood. The stump healed satisfactorily but slowly. In March of this year, ten months after the operation he saw the patient. The stump was well supplied by the circulation and there was no difference in appearance or size of this leg and the unoperated one.

Clinically this case was most successful but the exact meaning of the presence of arterial blood in the tibial arteries at the time of the amputation he did not know. It seems that the arterio venous anastomosis must have increased in some way the amount of blood in the leg, for it is hard to believe that an amount of blood so small as to permit gangrene of the foot would be sufficient to nourish for ten months an amputation stump made only a short distance above the gangrenous area and had clots formed at the sites of the anastomoses it seems most probable that the gangrene would have extended up the leg instead of remaining localized.

The second case was that of an old woman of 60 years with senile gangrene of the foot and a portion of the leg. The arteries were atheromatous. She was operated upon during February of

this year. The femoral artery and vein were divided as in the first operation. The artery was much calcified and was so hard that some force was necessary to drive the needles through it and so brittle that the stitches tore out most easily. The intima formed a distinct lining to the vessel and was much like a second smaller tube inside a larger one. These characteristics of the wall complicated the technique immensely as the attempt was to make the anastomosis according to Carrel's method, turning the walls so that at the suture line intima should come in contact with intima. The artery was so much like a pipe stem that this was impossible although a conscientious attempt was made. The ends of the artery and vein were therefore cut off freshly and the artery invaginated into the vein as in the first case the only difference being in the use of vaseline to smear the ends of the vessels. The distal end of the artery and the proximal end of the vein were then ligated. The vein pulsated after the controlling clamps were removed. Pagenstecker No. 1 was used. There was no shock and no change in the appearance of the leg. Ten days later it was necessary to amputate above the knee for the gangrene which had been present before the operation. During these ten days it had become more pronounced but its limits had extended only a little. During the amputation the anastomosis was cut down upon and removed. The artery was found filled with a loose, easily detached clot. This case was therefore a distinct failure.

From these cases he believed it to be perfectly evident that there is no danger in continuing investigations further as there is no shock to the operation. Carrel's method is not applicable to a certain number of the cases where the operation is done on old persons with atheromatous arteries. On young persons and experimental arteries it doubtless is most satisfactory but as the operation has been proposed to cure conditions dependent upon lack of circulation in the extremities some other technique must be found as practically all cases, except perhaps some due to trauma, will necessarily be in elderly persons. An objection which may be raised to the invagination method as employed in the above cases is the fact that the divided end of the artery leaves a certain portion of its wall in the blood stream uncovered by intima which favors clot formation. This method was introduced by Murphy in 1897 (*Medical Record*, Jan. 16) for the

repair of the continuity of an artery and was recommended only after experimentation. The slight modification of invaginating the artery into a vein instead of into another portion of the same artery would seem not to invalidate the method. However, as at present this objection might be raised, he was working on some scheme to obviate this difficulty, but as yet could not report results. Two ways had occurred to him. One is by smearing vaseline or some other substance onto the cut end of the invaginated artery to keep it out of the blood stream. The other way was suggested by the appearance of the arterial wall in the second case where the intima formed a distinct layer inside the others and one which remained intact when the others cracked away from it. He had thought that it might be possible to cut the outer layers of the artery a quarter of an inch or so back of the intima and thus leave a greater length of intima as a cuff, the back of which could be covered with vaseline so that when invaginated into the vein it might stick to the venous wall and cover over the cut end of the outer portion of the artery.

Dr. Robert H. M. Dawbarn, of New York, said Dr. Sweet's statement, that silk sutures were everywhere admitted to be the best, he must take exception to. A good many years ago Dr. Willy Meyer, of New York, proved by experiments that linen, cotton, and silk threads are tolerated equally well by the body tissues.

Of these linen is, size for size, the strongest, and is not seriously weakened by boiling; whereas silk is distinctly weakened.

For these reasons Dr. Dawbarn said he has not for years past used silk in surgery for any purpose whatever. In bowel and stomach work he has long advocated linen sutures—probably for ten years; though he would not bury it elsewhere in the body, except when exceedingly fine in diameter, as in Dr. Sweet's work upon arteries.

By asking at any large department store for such linen thread as is used in mending Renaissance lace, one can get size one thousand—which is as fine as can be used, practically, in vessel-work. It would seem to Dr. Dawbarn that if one employs women's finest sewing needles, removing the temper by heat enough to allow of curving them, and avoids having the thread

pass through the intima, so that it does not touch the blood current nor invite clotting, it might be a help. And yet Dr. Dawbarn did not wish to claim the least personal experience of work, such as that of Dr. Sweet, and would defer to his opinions in these matters.

Regarding Dr. Brewer's ingenious device for control of an important artery wounded accidentally at operation, Dr. Dawbarn said he must repeat his criticism offered upon the occasion when Dr. Brewer presented before the New York Surgical Society the results of his experimental work upon dogs. These experiments were very ably done, and the results satisfactory. To Dr. Brewer belongs the credit of the thought, and Dr. Dawbarn merely suggested a different material to wrap about the artery after its suture, and before allowing the current to be resumed; namely, Cargile membrane. This is always at hand, and, whether the adhesive or non-adhesive, will be equally satisfactory. It is very strong. After wrapping the vessel several times the final edge is sewn to the layer just beneath.

Being absorbable tissue it will in time disappear. As to the special kind of thin surgeon's rubber plaster advocated for this purpose by Dr. Brewer the life of rubber plaster is short, at best, and nobody would be likely to keep this specially thin kind on hand, and renewed often, to meet so very rare an accident. Also, being non-absorbable, it is capable at times of causing trouble later; becoming finally an irritant, however thoroughly aseptic it may be.

Dr. Dawbarn has tried upon two dogs' common carotids the gold-beater's skin adhesive plaster as just advocated by him, and with excellent results. The specimens, with others to be obtained by later work, he hopes to show in time.

Dr. Dudley P. Allen, of Cleveland, said his first experience in suturing vessels was in connection with wounds of the veins. The first case occurred between ten and twelve years ago. It was a wound of the longitudinal sinus, the length of the wound being ¾ of an inch. The wound occurred in an operation upon the brain and it was closed by a continuous suture of fine silk, the skull was re-placed, and healing took place without any complications.

There is one condition which has not been mentioned in

which suture of the vessels might prove to be of great value. Occasionally sarcomata develop in the popliteal space, being unattached to bone. It may be impossible before operation to tell whether the sarcoma surrounds the popliteal vessels or has pushed them to one side. If the vessels are surrounded, it may be necessary to divide them in order to remove the growth. Under such conditions, if a suture of the vessels could be successfully made it would be an operation of very great value. In a recent case it was necessary to divide the vessels and the operation was followed by gangrene of the leg which required amputation. Could an anastomosis have been made the leg might have been saved.

Dr. J. F. Binnie, of Kansas City, said that in a typical case of sacculated aneurism with one opening of moderate size he closed this opening with a suture and then obliterated the sac in the Matas' fashion thus performing a reconstructive operation although he did not at the time recognize the fact. In other cases, named by Matas fusiform aneurisms, there are two openings into the sac, these two openings being connected by a groove or strip of comparatively healthy vessel wall, along the wall of the sac. Such aneurisms are *not* fusiform, they are sacculated, only a narrow strip of one side of the vessel being diseased and constituting the sac. In this class reconstructive operations are of much value; there is sufficient healthy tissue to give a good prospect of success. Even if complete success is not attained, *i.e.*, if the newly created arterial tube becomes obliterated, this obliteration may take place slowly enough to permit the circulation being kept up while collateral circulation is being established. In true fusiform aneurism the whole circumference of the vessel wall is diseased—no healthy material remains out of which to construct an artery—hence in these cases the ordinary Matas' obliterative operation is proper and easy, the reconstructive operation is out of the question.

Dr. Munro, in closing, said he found in one case the same trouble experienced by Dr. Stewart. There was thrombosis of the femoral resulting from a fracture-dislocation. The clot stuck to the vessel wall and the artery was then opened below the thrombus and dislodgement attempted by hydrostatic pressure, but this was also unsuccessful.

DR. SWEET, in closing, said that the needles employed in arterial suture were so fine that if one attempted to sterilize and bend in a flame the steel would at once burn and be ruined. Regarding different suture material, silk probably has the finest individual strands and hence is to be considered better. A point to be considered in the case of arterio-venous anastomosis is that time is gained for the establishment of a collateral circulation.

DR. FRAZIER, in closing, said in answer to a question by Dr. Dawbarn regarding the control of hemorrhage from the femoral in operating upon aneurism, that the latter's suggestion to use McBurney's technic in securing a bloodless amputation by opening the abdomen and compressing the common iliac against the psoas was worthy of consideration.

DR. GIBBON, in closing, said regarding Dr. Stewart's suggestion that the vein be substituted for the artery, that in looking up the literature of the subject he had discovered the report of a case by Goyanes,[1] of Madrid, in which that suggestion had been put in practice. The popliteal was divided distally and the vein substituted for the artery, the expedient proving a success.

[1] (Siglo Mèdico, Sept. 8, 1906.)

BOOK REVIEWS.

A Study of the Human Blood Vessels in Health and Disease. By Arthur V. Meigs, M.D., Physician to the Pennsylvania Hospital, Philadelphia. J. B. Lippincott Company, 1907.

This is a supplementary work to the author's admirable book on "The Origin of Disease." It is the outcome of the author's studies of the blood vessels at the bedside, at the autopsy and in the laboratory. Dr. Meigs was placed under the fortunate circumstance of having to make his own pathological examinations upon patients dying in his hospital service. This inconvenience has the merit of bringing a man into closer relation with his cases than when the labor is subdivided with the pathologist.

The illustrations—one hundred and three in number—are all original. Among these are some steel engravings which were drawn directly upon the metal from the microscope without any intervening sketch.

The studies of the blood vessels have made advances, perhaps, greater than any other of the departments of pathological anatomy during the last ten years. This knowledge has been recorded in the current literature, but heretofore it has not been collected in a single text-book. Dr. Meigs has set down his own observations, but they have been made in the light of a familiarity with the observations of other investigators and hence embody a fairly full description of these conditions.

Dr. Meigs calls attention to his contention that there is a "disease of age," characterized by anatomical changes in the blood vessels. These changes are just as pathognomonic as are the anatomical changes in the lungs characteristic of pneumonia.

This book shows the development of new blood vessels in diseased tissues, in scars, adhesions and tumors, and also in the walls of diseased vessels. The constant tendency to the production of new fibroid tissue in all diseases is demonstrated.

The author's illustrations of giant-cells surely cannot be regarded as accurate; conditions are pictured as giant-cells which

it would seem to the reviewer should not be classified as such. In Fig. 25, K is clearly an illustration of an alveolar structure. That the so-called giant-cell is, properly speaking, no cell at all is very true, still pathologists are pretty well agreed as to just what collections of neuclei and protoplasm are to have this title, and the term has served a good use.

In studying the diseases of the vessel walls, the author has found that chalk may be deposited in any of the coats of an artery. One illustration is given showing chalk in the muscularis alone. The usual changes incident to old age are found in the intima, causing a thickening of that layer. Meigs contends that such a thing as a "physiological old age" does not exist.

One of the common causes of death in persons over fifty years of age is the rupture of a vessel of the brain. This is usually associated with pronounced disease of the intima. The author expresses it as his opinion that in apoplexy ulceration of the blood vessels is the precedent disease. This causes a slowly increasing thinning of the arterial wall until perforation takes place just as in typhoid perforation of the bowel. Apoplexy, he contends, is not due to the rupture of a stiffened vessel by reason of some extra effort or increase of arterial pressure. Commonly it comes during sleep or when the patient is quiet. He has found this ulceration in several cases, and he has even been able to discover the perforation through the ulcerated area. The ulceration is often latent and slow, and not uncommonly there are certain symptoms preceding the attack which are well known to clinicians.

This book after dealing with the diseases of the blood vessels in general takes up the diseases of the vessels of the various organs. It consists mostly in descriptions of specimens which the author has found. The larger part of the book is given to these descriptions without reference to any particular application of the knowledge revealed. The author expresses the hope that it may be of some use as further study of the blood vessels is made.

It is to be regretted that more light is not thrown upon the etiology and nature of varicose veins and of aneurism. The book is a painstaking and scientific contribution to our knowledge of this subject which reflects much credit upon its author.

JAMES P. WARBASSE.

CORRESPONDENCE.

INFLUENCE OF PREGNANCY ON CANCER OF THE BREAST.

EDITOR ANNALS OF SURGERY:

SIR:—The symposium on cancer of the breast in your July number covers the ground very satisfactorily except in one particular, viz: the relations of pregnancy to the disease in question. All surgeons are aware, and the point is emphasized in many text books, that cancer of the breast under the stimulus of pregnancy takes on a specially malignant character and runs a furiously rapid course. This fact was sadly exemplified in my experience a dozen years ago. A lady aged 29, mother of three children, became pregnant for the fourth time. She had had an abscess of the breast after her first confinement and there remained a nearly imperceptible cicatrix in the gland. This made no trouble during two succeeding pregnancies. About the third month of her fourth pregnancy, however, she complained that this old scar was enlarged and tender. Examination showed a swollen indurated mass and axillary and supra clavicular lymphatics enlarged. A well known surgeon saw her with me at once, diagnosed carcinoma of rapidly malignant type, and did a thorough extirpation of the breast and all lymphatic connections. The wound healed kindly, but in spite of the sweeping thoroughness of the removal the disease seemed scarcely to have been checked. It broke out at once all over the area of operation, ulcerating and discharging, and finally involved the pleura. I brought on labor early in the eighth month, saving the child, now a well-grown healthy boy; but the young mother died in what would have been the ninth month of pregnancy.

I was thus in a measure familiar with the behavior of mammary cancer in pregnancy, but it needed another case to open my dull eyes to the important corollary deducible from this knowledge.

In March, 1905, I operated for cancer in a lady aged 36, mother of three children, doing the usual thorough removal of

axillary contents, and a wide circumsection of the breast, necessitating skin-grafts to close the defect. The wound healed well, only a soft pliable scar remaining. All went smoothly till in December, 1905, the patient reported herself two months' pregnant, and examination verified her suspicion. Her danger was instantly clear to me, and I recommended termination of the pregnancy in order to avert the danger of its re-lighting the disease. This view being concurred in by a consultant, I emptied the uterus of a two month's embryo.

But even at the second month we were too late. I had thought the scar a trifle red and hard before the curettage, but soon after there could be no doubt. A flame of reddened lymphatics spread from the scar to the other breast, which was swollen and glossy with indurated œdema. The patient recognized her own condition and asked: "Did my pregnancy bring this back again?" I had no need to answer; she read the truth, and asked again: "*Then why did you not warn me?*" Sure enough, why had I not warned her?

Before the assizes of conscience I have pleaded that the thought was a new one to me, that I had not read or heard that women should be warned against pregnancy after extirpation of cancer of the breast; but I have never been able to clear myself of blame for this woman's shortened life, and I propose in future to include this warning in my duties to such patients.

It may be that others have recognized this duty, but if so they have neglected, so far as I know, to acquaint the profession with what now seems to me an important rule of conduct, viz., to warn breast cases of the danger of pregnancy.

WILLIAM S. CHEESMAN,
Auburn, N. Y.

AUGUST 8, 1907.

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